Surgical Management of Reproductive Emergencies

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Birthing in llamas and alpacas is a rapid process. Studies in South America documented that > 80% of crias (neonatal llama or alpaca) are born between 6 am and 1 pm.[3] Stage II labor (expulsion of the cria) occurs over a period of 10 to 15 minutes (range, six to 47 minutes).[3] Dystocia is an uncommon event in llamas and alpacas. Studies in South America found that dystocia in alpacas (1660 birthings observed) occurred in 1.6% of birthings and that 25% of these occurred in primiparous females. Data in a smaller number of llamas (234 birthings observed) demonstrated dystocia in only one female (0.4%).[3] Interestingly, causes of dystocia differ in South America and North America. Uterine torsion is rarely found in descriptions of dystocia in South America. Causes of dystocia in these populations include fetal malpositioning, with 30% of those occurring with the fetus in a posterior presentation and 70% in anterior presentation.[3] Markedly less information is available documenting causes of dystocia in North American herds.[1,5] What data is available seems to indicate that uterine torsion is a common cause for veterinary intervention of dystocia.[5,11] The author's opinion is that fetal malpositioning is associated with the majority of dystocia in llamas and alpacas and that uterine torsion is over-represented in the literature, because these cases are more likely to be presented to teaching hospitals for treatment.[1]

Uterine Torsion

The term "uterine torsion" refers to a condition where the pregnant uterine horn rotates along the long axis of the uterus from the normal position and does not return to a normal position. Uterine torsions are most often diagnosed because of abnormal clinical signs in either the dam or gestating fetus. In nearly all cases of diagnosed uterine torsion, the veterinary examination of the female is performed because of abnormal dam behavior noted by the owner. Uterine torsion was reported to account for 60% of dystocia cases presented to a veterinary teaching hospital[5] and has been reported to cause 30% of dystocias in Dromedary camels in another institution.[21] Discussions have occurred among veterinarians regarding the possibility that uterine torsion may occur and resolve without clinical signs being noted. The author has diagnosed uterine torsion in a llama as an incidental finding during routine pregnancy examination. The diagnosis was made during rectal palpation of the uterus in a five-year-old llama which had a fetus consistent with a six to seven month gestation. A right horn pregnancy was present, with a > 270 counter-clockwise rotation. In this case, no clinical signs of distress were noted in either the dam or fetus and the torsion was not addressed. On re-evaluation 24 hours later, the torsion was no longer present and the female carried the pregnancy to term and gave birth to a healthy cria. This observation is offered only as an illustration that uterine torsions likely occur at some stages of pregnancy without our knowledge and without causing harm. The author does not advocate delays in treatment of uterine torsion, especially when clinical signs are present. The author feels that uterine torsion should be addressed as an emergency in order to save the life of the dam and the fetus. Fatalities of the fetus and dam have been observed because of delays in treatment and deaths have been caused by ischemia to the uterus, rupture of the uterus, and fatal hemorrhage into the abdomen.

Uterine torsion most commonly occurs in late gestation in llamas and alpacas, with most cases occurring after the ninth month of gestation. In a report of 20 uterine torsions in llamas and alpacas, 90% of the affected females were > 335 days gestation.[5] Unlike horses and cattle in which uterine torsion most often occurs at term, uterine torsion in alpacas and lamas frequently occurs two to six weeks before the due date for parturition. When possible, the author leaves the gestating cria in utero to continue to a natural birthing process (e.g. in females having a uterine torsion > two weeks prepartum and closed cervix). Poor survival of crias born after having induction of parturition or born prematurely has been reported.[4] In that study, induction of parturition was attempted with fluprostenol, oxytocin, or three different dosages of dexamethasone. Alpacas given fluprostenol delivered a live cria a mean of 21.5 hours after treatment. Oxytocin and dexamethasone at < 0.05 mg/kg failed to induce parturition. Dexamethasone at 0.5 mg/kg resulted in stillborn fetuses. Thus, neither oxytocin nor dexamethasone should be used for induction of parturition in alpacas. The author routinely monitors fetal heart rate, placental thickness, and placental fluid echogenicity to assess fetal well being. Cesarian section is performed if the cria is determined to be at risk. Ultrasonographic monitoring of the cria can include echotexture of the fluids within the heart and body cavities of the cria. Evidence of impending fetal distress include decreasing heart rate, placental fluids developing

a turbid appearance on ultrasonography, rapid changes in placental thickness, and apparent separation of the placenta from the endometrium.

The ability to diagnose the direction of uterine torsion is critical to non-surgical correction. Failure to correctly diagnose the direction of torsion before attempting correction by rolling can cause exacerbation of the torsion, loss of blood flow to the fetus, or ischemia to the uterus. The direction of the rotation of the uterine horns can be described as either clockwise (torsion of the left horn to the right side) or counter-clockwise (torsion of the right horn to the left side). This refers to the direction of rotation of the gravid uterine horn about the long axis of the uterus and the non-gravid horn similar to the direction of the rotation of the hands of a clock. This terminology assumes that the observer is standing behind the animal and looking at the rear end of the llama or alpaca. The rear quarters are used to visualize a clock face with the vulva at the center. In a normal, non-gravid uterus, the uterine horns are positioned at 3 o'clock (right horn) and 9 o'clock (left horn) on the clock face. During pregnancy, the gravid horn of the uterus (long or minute arm of the clock) rotates ventrally and toward midline because of gravity. This shifting of the gravid horn creates a 90 degree rotation ipsilateral to the gravid horn. Although the uterus is rotated, the broad ligaments of the uterus are parallel and course from the caudo-dorsal attachments in a cranio-ventral position. The broad ligaments remain relatively parallel to each other and become more obvious as the pregnancy advances and the uterus becomes laiden with fluid.

Uterine torsions are based (maximum point of gravity) in the gravid horn. Thus, clockwise torsions occur when a left horn pregnancy is present and counter-clockwise torsions occur when a right horn pregnancy is present. In the situation when the left horn (minute hand) rotates dorsal and lateral to the right horn (hour hand), then the horn is described as having moved clockwise similar to the hands of the clock. In the situation of a counter-clockwise uterine torsion, a right horn pregnancy is present and the gravid right horn (minute hand) rotates dorsal and lateral to the left horn (hour hand) of the uterus. The torsion can be anywhere from 90 degrees to 360 degrees and beyond. The caudal extent of the torsion is normally near the cervix, but may be based in the uterine body cranial to the cervix or in the vagina caudal to the cervix. In term pregnancies, the torsion often prevents the cervix from dilating fully and will prevent birth if it is not corrected. In a report of 20 occurrences of uterine torsions diagnosed in 11 llamas and three alpacas, 95% were in a clockwise direction.[5] Interestingly, the author found that of 13 uterine torsions diagnosed in 10 alpacas and three llamas, 60% were in a counter-clockwise direction (Anderson, unpublished data). These differences exemplify the need for accurate diagnosis of the direction of uterine torsion before attempting non-surgical correction.

The cause of uterine torsion is unknown. Studies in other species have documented risk factors including large fetal size, having a male fetus, breed predispositions, and maternal illness.[10] In the author's opinion, dam behaviors such as rolling excessively, right horn pregnancies, and prolonged gestation are associated with increased risk of uterine torsions. Excessive rolling is often seen when females are moved to a new area during late gestation, such as to a new pasture or to maternity pens or barns.

Clinical signs of uterine torsion are variable. Clinical signs range from mild–including depression, lethargy, reluctance to rise, and anorexia–to more severe signs of colic, including increased heart rate and respiratory rate, rolling, thrashing, vocalizing, and straining without effect. Uterine torsion should be suspected when a dam is in late gestation and shows signs of abnormal behavior, distress, abnormal labor, or labor without progression.

Vaginal speculum examination or transvaginal palpation can be used to diagnose the presence of a uterine torsion in many cases. A vaginal speculum is placed into the vagina and the vestibule is inspected for deviations, compression, or twisting of the walls of the vagina or vestibule. The author prefers to use a human rigid sigmoidoscope for vaginoscopic examinations, but any suitably sized and cleansed tube and light source may be used. Diagnosis of uterine torsion is made when the vaginal vault is twisted and narrowed and the direction of the torsion is inferred by the direction of the twisting or distortion of the vaginal vault. However, the examiner must understand that distortion of the vagina is consistently observed only with post-cervical uterine torsion. The author has diagnosed many cases of uterine torsion where the vaginal examination has been non-diagnostic. In the author's opinion, rectal examination or exploratory laparotomy are the prefered methods for definitive diagnosis of uterine torsion.

Careful rectal plapation can be used to identify the uterus and broad ligaments. In the author's experience, the broad ligaments are thinner, more pliable, and less easily defined compared with that of cattle and horses. Thus, some experience is required to accurately identify the uterus and broad ligaments. Rectal examination must be performed carefully so as not to perforate the rectum. Techniques used to increased the safety of rectal palpation include restraint in a camelid stocks, sedation with drugs having analgesic properties (e.g. narcotics, alpha-2 agonists), use of large quantities of obstetrical lubricant, epidural anesthesia (e.g. 2% lidocaine HCl), and application of lidocaine jelly directly on the anal sphincter and in the rectal lumen. Diagnosis of uterine torsion is based on palpation of deviation of the broad

ligaments. Normally, both broad ligaments course from caudal and dorsal in the pelvic canal to cranial and ventral in the abdomen. In the presence of a uterine torsion, the broad ligament associated with the gravid uterine horn courses from caudal and dorsal to the horn, across the pelvic canal dorsal to the cervix and uterine body, and cranial and ventral to the contralateral side of the abdomen. The broad ligament associated with the non-gravid horn courses from caudal and dorsal in the pelvic canal, can be felt continuing ventral to the cervix and uterine body, but cannot be palpated as it continues cranial and ventral in the abdomen.

Rectal palpation is often difficult in alpacas because of their small size, but most mature llamas can be palpated if proper precautions are observed. A solid-sided llama or alpaca restraint chute is important to allow easy and efficient reproductive examinations. Performing these diagnostic tools on free standing females or females pressed against a wall are stressful for the patient, veterinarian, and owner. Sedation should be used sparingly. When needed, butorphanol tartrate (0.1 mg/kg IV) provides excellent sedation with minimal to no untoward effects on the fetus. Before rectal palpation, I prefer to place 60 to 100 mL of lubricant into the lumen of the rectum. In small females, 5 mL of lidocaine can be added to help relax the anal sphincter. If the female is fractious, epidural anesthesia (lidocaine HCl 2%, 1 mL/45 kg [100 lb] maximum dose) may be used. Rectal palpation should be performed with caution because rectal tears have occurred in llamas and alpacas. The examiner should make the owner aware that bleeding from the anal sphincter is common when rectal palpation is performed. This is caused by over-stretching of the mucous membrane and sphincter muscle. This is unlikely to pose a risk to the animal, but does cause swelling and discomfort. Rectal examination should be used to assess fetal movement, uterine tone, position of the broad ligaments, and the presence of adhesions or other periuterine masses. An interesting observation is that we have found the head and front limbs of the fetus within the pelvic canal up to three months before parturition. Also, we have failed to find the head and feet of the fetus within the pelvic canal as early as three days before parturition in llamas and alpacas that ultimately delivered a cria in a anterior, longitudinal, dorsosacral position.

Uterine torsion can be corrected either with medical or surgical intervention. Medical intervention generally entails rolling the female while stabilizing the uterus to "untwist" the torsion. Transvaginal correction can be done if cervical dilation is sufficient for entry of a hand into the uterus alongside of the fetus. In a report of 20 uterine torsions diagnosed in 14 llamas and alpacas, five were corrected by transvaginal manipulation and eight were corrected by rolling of the dam combined with application of external compression on the abdomen.[5] If sedation is needed to roll the dam, the author prefers to use a mixed agonist-antagonist narcotic (e.g. butorphanol, 0.05 to 0.1 mg/kg, IV) to minimize cardiopulmonary effects on the dam and fetus. The rolling procedure is done by placing the dam on the same side as the direction of the torsion. For example, if a llama has a clockwise uterine torsion (twist to the right, left horn over top of right horn), then the llama would be placed on her right side to begin the procedure. Then, transabdominal palpation is used to identify and stabilize the gravid horn of the uterus by feeling the fetus. Most often, the backbone of the fetus is present along the abdominal wall. While maintaining pressure on the gravid horn, the female is rolled over her back to her other side. Alternatively, a plank has been used on the outside of the abdomen to help keep the uterus in place while the dam is rolled. This procedure may need to be repeated multiple times. The author's rule of thumb is "three times and you're cut"–meaning that if the torsion cannot be corrected within three attempts, then surgical correction is done. A rectal examination is done after each attempt to determine the extent of correction. Correction of the torsion is confirmed by palpating the broad ligaments, uterine body, and fetus. If rolling is successful the dam should be walked, but not allowed to roll, for 30 minutes to one hour and then re-examined. In the author's experience, uterine torsion often reoccurs within a short period of time in up to 20% of females. This may be associated with incomplete correction during the rolling procedure. If rolling is not successful, a decision should be quickly made regarding surgical correction.

Surgical correction of uterine torsion can be done under clean field conditions. In a case report of 20 uterine torsions, seven required celiotomy to correct the torsion.[5] For flank procedures, the hair overlying the left paralumbar region of the llama or alpaca is clipped using a number 40 clipper blade. Then, the skin is aseptically prepared for surgery. The proposed site of the incision is anesthetized using 2% lidocaine HCl. Care must be taken to minimize the total dose of lidocaine used because llamas and alpacas are more susceptible to lidocaine toxicity than cattle. The author uses a dose of 4 mg/kg body weight as the maximum tolerable dose of lidocaine. The author prefers to approach the abdomen from a left-sided laparotomy.[2] Care must be taken in this approach because, unlike cattle, sheep, and goats, the spleen of llamas and alpacas is positioned in the mid-portion of the flank region. The spleen can be easily injured during opening of the transversus abdominus muscle and peritoneum. The site for paralumbar incision is made starting at a point 6 to 8 cm cranial and ventral to the tuber coxae and extending 8 to 10 cm cranially and ventrally toward the costochondral junction. The incision is made only large enough for the surgeon to introduce

a hand and arm so that the uterus can be corrected in position blindly. If the cria is known to be compromised, a 15-cm incision will accommodate exteriorization of the uterus for C-section. If a left-flank laparotomy is being done for correction of a clockwise uterine torsion, then the left uterine horn (gravid horn) must be grasped using the hand to cup the hock bone of the fetus, pushed to the right side, then elevated dorsally and then to the left side. If a left laparotomy is being done for a counterclockwise torsion, then the right horn of the uterus is located and a cupped hand used to pull the fetus toward the left side and then moved dorsally and toward the right side. Correction of the torsion is confirmed by palpating the broad ligaments, uterine body, and fetus. After the torsion has been corrected and the viability of the fetus confirmed, the laparotomy incision is closed in two layers. The abdominal muscles and fascia of llamas and alpacas is thin and has poor holding power for sutures. Careful reconstruction of the abdominal wall with size No. 1 synthetic, absorbable suture material having good retention of tensile strength (e.g. PG-910; PDS) is done. Then, the skin is closed using No 1 nylon or polycaprolactam with a continuous interlocking suture pattern. If the fetus is at term (partially open cervix), compromised, or determined to be dead, a C-section can be performed at the same time. In rare cases, the uterus cannot be corrected without removal of the fetus. This is a judgment call that the surgeon makes during procedure. The author prefers to leave the fetus in situ when the uterine torsion has occurred sufficiently preterm so as to pose high risk for survival outside of the uterine environment. In a report of seven celiotomies done to correct uterine torsion, six were done in term females. In these six females, the crias were removed by hysterotomy and four (66%) of the crias survived. In the remaining female, the fetus was left in situ and was delivered stillborn at a later date.

Uterine torsion presents a significant risk to the live of the dam and cria. Death has been seen in dams because of hemorrhagic shock, toxemia associated with uterine ischemia, septic peritonitis, and acute catastrophic events (e.g. cerebellar herniation 10 days post-non-surgical correction of a uterine torsion in a three-year-old alpaca). Possible complications of uterine torsion can include fetal death or compromise, premature birth, death of the dam, uterine compromise by ischemia, rupture of the uterine or ovarian artery with hemorrhage, uterine rupture and subsequent peritonitis and, if surgical correction is necessary, all of the complications associated with laparotomy and C-section such as retained placenta, metritis, and adhesions.

Return to breeding soundness is of concern to breeders. Of 14 llamas and alpacas having uterine torsion on 20 occasions, non-surgical correction was successful in 13 and celiotomy was required in seven.[5] Of 20 occasions of uterine torsion, 14 crias were born or delivered alive and six crias were stillborn. All camelids having non-surgical correction of uterine torsion successfully returned to breeding; five out of seven camelids having celiotomy returned to breeding soundness.

Fetal death or disability has been seen because of diminished fetal blood flow, placental edema, placental separation, and trauma. Based on the author's experience, we expect a > 80% maternal survival rate and a > 70% fetal survival rate. Frequent evaluation of the dam and fetus if transvaginal delivery or C-section is not done are useful in determining if the fetus is at risk. Careful and detailed evaluation on a regular basis (e.g. q8 hours or q12hours) can allow intervention and emergency delivery of the fetus if needed. The author uses a combination of dam behavior, ultrasonography, fetal heart rate, and fetal cardiotocography to monitor the condition of the placenta and fetus.[3,13-15]

Cesarean Section

Dystocia is relatively uncommon in llamas and alpacas. In South America fewer than 2%, and in North America fewer than 5%, of birthings are expected to require assistance.[3,12,20] 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 20 minutes or more after the start of stage II labor. The most common causes of dystocia in llamas and alpacas are fetal malpositioning, uterine torsion, and poor cervical dilation.[5]

Patient assessment is critical to successful alleviation of dystocia.[1,2] 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 (e.g. 0.9% saline, 45 ml/kg [100 lb] body weight over one hour; hetastarch, 10 ml/kg body weight over 30 minutes). Non-steroidal anti-inflammatory drugs (e.g. flunixin meglumine, 1 mg/kg, IV) and/or antibiotics (e.g. ceftiofur, 2 mg/kg body weight, IV) may be used when appropriate. If the dam is stable or after supportive therapy has been initiated in the dam, the presentation, position, and posture of the fetus and presence and extent of vaginal and uterine injury should be determined. If the size of the dam precludes evaluation of the uterus or fetus, then ultrasonography may be done to assess the fetus. Immediate exploratory surgery and C-section may be the most prudent action if labor has been prolonged, fetal heart rate cannot be assessed, or the condition of the fetus or birth canal precludes transvaginal delivery.

Dystocia may be relieved without surgery if the following criterion can be achieved: 1) the cervix is adequately dilated and the pelvis is of adequate size to extract the fetus, 2) the pelvic dimension allows introduc-

tion of a hand into the uterus for fetal manipulation, and 3) the uterus has sufficient room to grasp and manipulate the fetus. If these criteria cannot be met, the decision to perform a C-section should be made without delay. In my experience, uterine laceration is more likely to occur in llamas and alpacas compared with sheep or cattle. Thus caution, liberal lubrication, and restraint or sedation of the dam are useful to successful resolution of dystocia.

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 the size of the dam precludes transvaginal palpation, immediate C-section should be chosen. Delay in the decision to perform surgery may result in fetal and/or maternal death. Unlike cattle, fetal maturity is highly variable in llamas and alpacas. Although induction of parturition and elective C-section are commonly and successfully performed in cattle with expectation for both maternal and calf viability, this has not been found in llamas and alpacas. In a study of induction of parturition in term alpacas, fetal mortality rates varied from 40 to 90%.[4] Thus, the author does not recommend elective C-section in llamas or alpacas. If maternal conditions (e.g. pelvic fracture or neoplasia) require C-section, the author prefers to allow the female to enter into Stage I labor before scheduling surgery.

Cesarean section is most easily performed via paralumbar fossa or ventral midline laparotomy. Ventral midline laparotomy for C-section has been recommended, but is best performed with the dam under general anesthesia.[9] The author prefers to perform C-section via a left paralumbar approach. This allows C-section to be performed with the dam sedated and restrained in right lateral recumbency but not anesthestized (Table 1).[7,18,19,22,23] In my experience, crias are more vital and maternal-neonate bonding occurs more readily. Also, milk let-down and early lactation are expected to be more rapid. General anesthesia is discussed elsewhere in this text. A useful sedative for left laparotomy is butorphanol (Table 1). If necessary based on maternal activity, xylazine may be used (Table 1). Clinical depression of the fetus is minimal and xylazine may be reversed using yohimbine or tolazoline (Table 1) if needed. The female is haltered, laid down in right lateral recumbency, and the head and limbs are tied to prevent excessive movement. Then, lidocaine HCl 2% is used to establish a line block at the site of the incision. Caution should be used not to exceed 4 mg/kg body weight total dose of lidocaine (1 ml per 5 kg body weight) so as not to induce lidocaine toxicity. Lidocaine toxicity is recognized by lethargy, ataxia, slow and labored breathing, weakness, hypotension, and diminished response to stimuli.

The skin incision is begun approximately 8 to 10 cm cranial and ventral to the tuber coxae and is extended cranially and ventrally approximately 15 cm in length toward the costochondral junction. Care must be taken when incising the external abdominal oblique muscle, internal abdominal oblique muscle, and the transversus abdominus muscle so as not to invade the peritoneal cavity prematurely. With the left side approach, the C1, spleen, and left kidney lay positioned against the abdomi-

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 + Xylazine + Ketamine	0.03 mg/kg 0.3 mg/kg 3 mg/kg	IM IM IM
	Tiletamine/zolazepam Halothane Isoflurane	4.7 to 6.0 mg/kg 1 to 5 % 1 to 5 %	IM OTT or 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[19] and Waldridge[22].

nal wall and can be inadvertently lacerated during entry. On the right side of the abdomen, the C3, duodenum, right kidney, and small intestine lay positioned close to the abdominal wall. The uterus should be exteriorized from the abdomen if possible to prevent leakage of uterine fluids into the abdomen. This is critical if extensive attempts at manual correction of dystocia have been tried or if the fetus is dead or emphysematous. The uterus is remarkably thin and care should be exercised when opening the uterus so as not to cause injury to the fetus. In most cases, the placenta is left in situ after extraction of the fetus. If the placenta can be easily separated from the endometrial wall, it may be removed at the time of hysterotomy. In the author's experience, the placenta is not easily removed and should be left in place so as not to cause excessive endometrial hemorrhage.

In most llamas and alpacas, the healthy uterus can be closed in a single layer with No 0 polydioxanone or polyglecaprone. When uterine laceration or compromise to the uterine wall is present (e.g. edema, mural hematoma), a double layer closure should be done to ensure that an adequate serosal seal is achieved. The uterus should be thoroughly lavaged clean of all blood clots prior to being replaced into the abdomen. However, the surgeon should not use gauze pads or other abrasive materials to remove blood or fibrin because this will increase the likelihood of postoperative adhesions. In cases where preoperative uterine rupture occurred or the uterus is traumatized during surgery, carboxymethyl cellulose has been evaluated and advocated for prophylaxis against postoperative uterine adhesions.[8,16]

Ventral midline celiotomy incisions can be closed in interrupted or simple continuous suture patterns. The author uses No 1 polydioxanone or PG-910 suture material in the linea alba. Contrary to expectations in many species, paralumbar incisions have a greater risk of postoperative incisional hernia as compared with ventral midline incisions. The muscle layers should be precisely reconstructed in simple continuous suture patterns. The author prefers No 1 PG-910 or PGA because of the supple nature of the suture and tissue-holding characteristics in muscle. The skin can be apposed using No 1 nylon or polypropylene suture in an interrupted or Ford interlocking suture pattern. After surgery and when the dam is standing, an abdominal support bandage can be used to minimize incision strain for 10 to 14 days. This may minimize the risk of incisional hernia.

Antibiotics and non-steroidal anti-inflammatory drugs are administered routinely before surgery and continuing for three days after surgery. Therapy may be prolonged if uterine laceration, abdominal contamination, or emphysematous fetus were present. Close attention should be paid to the cardiovascular stability of the dam and respiratory rate, heart rate, and rectal temperature should be determined twice 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 postpartum uterus. In a review of 576 uterine microbial cultures from llamas and alpacas, *Actinomyces*, alpha-*Streptococcus*, and *E. coli* were the most commonly isolated bacteria. Thus, antimicrobial selection should include both gram-positive and gram-negative spectrum.

Complications of laparotomy include peritonitis, hemorrhage, incisional seroma or hematoma, incisional infection, incisional dehiscence, and incisional hernia. These complications are infrequent when aseptic technique, careful tissue handling, and accurate reconstruction of tissues using appropriate materials and techniques are used.

Complications of C-section include peritonitis, uterine adhesions, para-ovarian adhesions, retained placenta, metritis, endometritis, and infertility. Early decision for C-section will optimize the condition of the dam, fetus and tissues, and therefore minimize the risk of complications. Retention of the placenta is expected but the placenta is expected to pass within 48 to 72 hours after surgery with minimal to no treatment. The author routinely administers cloprostenol (250 ug total dose, IM) on the day of surgery to ensure lysis of the corpus luteum (CL) and continuation of placental separation from the endometrium. Caution should be observed with the use of oxytocin. Oxytocin should only be used in the presence of an open cervix (5 units, IM, every two hours for two to four treatments). Oxytocin has been associated with abdominal pain in llamas and alpacas, and the dosage and response to therapy should be closely monitored.

Cesarean section is one of the most common surgical procedures requested for large animal 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 in llamas and alpacas include retained placenta, uterine prolapse, and infertility.[5] Out of seven llamas and alpacas having C-section for correction of uterine torsion, five animals successfully conceived a pregnancy after uterine torsion correction. Overall, we expect 75% of females that have had a C-section to return to normal breeding soundness.

References

1. Anderson DE, Cotton TA, Whitehead CE: Female reproduction, in Anderson DE, Cotton T, Whitehead CE (eds): *Neonatology of Llamas and Alpacas*, Kansas State University Continuing Education publication, 2008, pp 51-197.

2. Anderson DE: Common surgical procedures in camelids. *Journal of Camel Practice and Research* 6:191-201, 1999.
3. Bravo PW: Female reproduction, *The Reproductive Process of South American Camelids*, Salt Lake City, Seagull Printing, pp 1-31, 2002.
4. Bravo PW, Bazan PJ, Troedsson MH, Villalta PR, Garnica JP: Induction of parturition in alpacas and subsequent survival of neonates. *J Am Vet Med Assoc* 209:1760-1762, 1996.
5. Cebra CK, Cebra ML, Garry FB, Johnson LW: Surgical and nonsurgical correction of uterine torsion in New World camelids: 20 cases (1990-1996). *J Am Vet Med Assoc* 211:600-602, 1997.
6. Deans AC, Steer PJ: The use of the fetal electrocardiogram in labor. *Br J Obstetrics and Gynecology*, 101:9-17, 1994.
7. Elias E: Left ventrolateral Cesarean section in three Dromedary camels (*Camelus dromedarius*). *Vet Surg* 20:323-325, 1991.
8. Ewoldt JM, Anderson DE, Hardy J, Weisbrode SE: Evaluation of a sheep laparoscopic uterine trauma model and repeat laparoscopy for evaluation of adhesion formation and prevention with sodium carboxymethylcellulose. *Vet Surg* 33:668-672, 2004.
9. Fowler ME: Cesarean section, in Fowler ME (ed): *Medicine and Surgery of South American Camelids*, ed 2. Ames, Iowa State University Press, 1998, pp 130-132.
10. Frazer GS, Perkins NR, Constable PD: Bovine uterine torsions: 164 hospital referral cases. *Therio* 46:739-758, 1996.
11. Hopkins SM, Althouse GC, Jackson LL, Evans LE: Surgical treatment of uterine torsion in a llama (Lama glama). *Cornell Vet* 81:425-428, 1991.
12. Johnson LW: Parturition in the llama, in Youngquist RS (ed): *Current Therapy in Large Animal Theriogenology*. Philadelphia, WB Saunders 1997, pp 813-817.
13. Jonker FH: Cardiotocographic monitoring of the bovine fetus. University of Utrecht (ISBN 90-393-0425-4), 1993 (171 pages).
14. Jonker FH, van Oord HA, van Geijn HP, *et al*: Feasibility of continuous recording of fetal heart rate in the near term bovine fetus by means of transabdominal doppler. *Vet Quarterly* 16:165-168, 1994.
15. Jonker FH, van Geijn HP, Chan WW, *et al*: Characteristics of fetal heart rate changes during the expulsive stage of bovine parturition in relation to fetal outcome. *Am J Vet Res* 57:1373-1381, 1996.
16. 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.
17. Rabello YA, Lapidus MR: Fundamentals of electronic fetal monitoring. Corometrics Medical Systems, Inc, Wallingford, CT, 1988 (162 pages).
18. Reibold TW, Engel HN, Grubb TL, Adams JG, Huber MJ, Schmotzer WB: Orotracheal and nasotracheal intubation in llamas. *J Am Vet Med Assoc* 204:779-783, 1994.
19. Sarno RJ, Hunter RL, Franklin WL: Immobilization of guanacos by use of tiletamine/zolazepam. *J Am Vet Med Assoc* 208:408-409, 1996.
20. Sharpe M, Wittum T, Lord L, Anderson DE: Epidemiologic survey of morbidity and mortality among crias. *Aust Vet J*, 2009, in press.
21. Tibary A, Anouassi A: Genital diseases in the pregnant female. *Theriogenology in Camelidae*. Abu Dhabi Printing and Publishing Company, UAE, 1997, pp 353-363.
22. Waldridge BM, Hui-Chu L, DeGraves FJ, *et al*: Sedaticve effects of metdetomidine and its reversal in llamas. *J Am Vet Med Assoc* 211:1562-1565, 1997.
23. Wilson DG: Surgery of the genitalia of llamas, in Youngquist RS (ed): *Current Therapy in Large Animal Theriogenology*. Philadelphia, WB Saunders, 1997, pp 840-843.