C-Section in Small Ruminants

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Occurrence of dystocia

Dystocia is relatively uncommon in with a herd goal of fewer than 5 % of birthings requiring assistance. 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. Stage I labor is defined as preparation for fetal expulsion and includes restlessness, decreased appetite, isolation from the herd, preparing a birthing area, and leading up to the early uterine contractions. Stage II labor is defined as fetal expulsion. In other words, uterine contractions up to, including, and completion of delivery of the neonate. Stage III labor is defined as uterine contractions causing expulsion of the placenta and remaining fetal fluids.

In small ruminants, dystocia most often is caused by fetal malpositioning, fetal:maternal disproportion, multiple fetuses within the pelvic canal simultaneously, incomplete dilation of the cervix (ringwomb), and uterine inertia but uterine torsion can also occur. Uterine torsion is defined as extreme twisting of the uterus on its long axis. The uterus normally rotates along a 90 degree arch and may intermittently move more than that during uneventful gesttaion. When the gravid (pregnant) uterine horn flips over top of the nongravid uterine horn causing the uterine to twist 270 degrees or more, the torsion is so abnormal that it can not be corrected by the animal and the life of the fetus and dam are at risk. In a study of 110 C-sections performed in sheep and goats, sheep were most commonly admitted to the VMTH for C-section as compared with goats. Pygmy goats were the most likely goat breed to require C-section. Inadequate cervical dilation was the most common reason given for C-section.

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 may need to have an IV catheter placed and crystalloid fluids administered. Non-steroidal anti-inflammatory drugs also may be used (e.g. flunixin meglumine or Banamine). 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 radiographs may be done to assess the fetus. However, immediate exploratory surgery and C-section may be a more prudent action. In a study of sheep having C-section done, Scott et al (1989) reported that vaginal prolapse did not influence the survival rate of ewes. However, forced attempts at manual extract with trauma to the pelvic rreproductive structures prior to veterinary intervention adversely effected dam survival. In that study, ewes having had vaginal prolapse during gestation were 10 times more likely to require a C-section. Thus, ewes having had vaginal prolapse should be selected for more rpaid decision making with regard to the selection of C-section for management of dystocia.

Decision for non-surgical treatment

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 introduction of a hand into the uterus for fetal manipulation, 3) the 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 criterion can not 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 (e.g. ringwomb) immediate C-section may be indicated. Damage to the cervix or uterus is more likely when trying to force manipulation of the fetus despite inadequate space or cervical dilation. The author has seen multiple goats with severe vaginal stricture caused by manual extraction of kids with concomitant damage to the cervix and vagina. If the size of the dam precludes transvaginal palpation, immediate C-section may 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 - especially pygmy goats, compared with sheep or cattle. Ina review of 137 C-section performed in sheep on the farm, 97.8% of the sheep survived the surgery when the C-section was performed with a live lamb or freshly dead lamb. When the lamb was dead long enough o begin autolysis or had become emphysematous, the survival of dams decreased to 57%. Thus, early decision making is critical to success.

Cesarean section (hysterotomy)

Cesarean section may be performed via paralumbar fossa (left side may be better than the right side), low flank or ventrolateral incision (left better than right), lateral oblique, or ventral midline laparotomy. Flank procedures are performed after local anesthesia but ventral midline procedures are best done under general anesthesia. Lidocaine toxicity may occur if > 4 mg/kg body weight of lidocaine is administered (e.g. the maximum safe dose of lidocaine is 1 ml of 2% lidocaine HCl per 10 lbs (5 kg) body weight). In a

study comparing the use of local anesthesia versus general anesthesia with thiopentone for C-section in ewes, lambs born under general anesthesia were more likely to have acidosis associated with increased blood CO2 (Copland 1976). Thus local anesthesia, with or without sedation, is our method of choice for C-sections in small ruminants.

Ina retrospective study of 110 C-sections, the left paralumbar fossae was the most common surgical approach to the abdomen choosen (Brounts 2004). 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 PDS or Monocryl in a double layer closure. Little data exists to provide details of outcomes of C-section in sheep or goats. De Wit performed hysterotomies in 202 cows and compared hysterotomy closure with vicryl to that using 9 metric 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 using sterile saline solution prior to being replaced into the abdomen. I prefer to place an OB solution, composed of 500 ml isotonic saline solution containing antibiotics (K-penicillin G 22,000 U/kg, Na-ampicillin 20 mg/kg, or Na-ceftiofur 1 mg/kg), anti-inflammatory drugs (flunixin 1 mg/kg), and anticoagulants (heparin 20 units/kg), into the abdomen immediately prior to closure of the incision. Carboxymethyl cellulose (CMC 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.

Fetal viability is often predicated on fetal stress prior to surgery. In a retrospective by Brounts et al 2004, 55% of lambs and kids delivered by C-section were dead at the time of surgery and most of these dams had been in Stage II labor for > 6 hours before C-section.

Uterine torsion

Uterine torsion most commonly occurs in llamas and alpacas and usually occurs within the last month of the pregnancy. Uterine torsion is uncommon in sheep andgoats but has been recognized. Most (~70 %) of uterine torsions in camelids may be corrected by rolling, but surgery is indicated if correction is not achieved with 2 attempts. Uterine torsion usually occurs at the termination of gestation and occurs more often with overweight – often male – crias, but does not have a clear age or season predisposition. Clinical signs include fever, tachycardia, tachypnea, anorexia, straining, and vaginal discharge. Camelids may show signs of abdominal pain or may simply lay down and appear to be depressed. Uterine torsion can often be corrected without surgery. When the uterus can not be corrected by rolling (~30 %), when the cervix does not dilate sufficiently to deliver the fetus, or when fetal proportion or anomalies prevent delivery of the fetus, C-section may be indicated. However, we have found that fetal survivability is better if the uterine torsion can be corrected (either by rolling or by surgery) without the cria being delivered. We have had a 95% cria survival rate if we allow the cria to continue gestation to term after correction of the torsion. This compares to a 80 to 90% survival rate when immediate C-section is chosen. I prefer to perform left paralumbar fossa laparotomy regardless of the direction of the torsion. There does seem to be a difference in the direction of uterine torsion between llamas and alpacas. Llamas seem to be more prone to clockwise (left horn pregnancy) torsions whereas alpacas are more balanced (counterclockwise torsions – right horn pregnancies- are slightly more common in our experience). Although many authors advocate correcting the torsion prior to hysterotomy, I perform hysterotomy immediately upon exteriorization of the uterus. I have found that, in many cases, hysterotomy is more easily performed before correction of the uterus. Dam survival is expected to be good to excellent, cria survival is expected to be fair to good, retained placentas are common, but return to breeding soundness is expected to be good.

Post-operative care

The most common complication post-C-section is retained placental membranes. Ina retrospective study of 110 C-section in sheep andgoats, 40% of the cases had retained placentas after surgery. Antibiotics and non-steroidal anti-inflammatory drugs are administered for 3 days after surgery. Therapy may be prolonged for 5 to 7 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 5 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 (Actinomyces pyogenes, E coli) and may include procaine penicillin G (22000 U/kg, IM or sc, q24hr), Na-ceftiofur (1 mg/kg, IM or sc, q24hr), or tetracycline (20 mg/kg, IM or sc, q24hr). I also administer flunixin meglumine (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. Relatively little literature is available regarding re-breeding success after C-section in shepe and goats. Cattell et al reported on results of 133 C-sections in cattle. Approximately 91 % of the cows and 95 % of the calves that were alive at the start of surgery survived. Approximately 30 % of the cows suffered an illness (poor appetite, fever, metritis, diarrhea) after surgery. Only 22 beef and 24 dairy cows were re-bred after surgery. Calving to first service interval was 81 ± 29 days for dairy cows, calving to conception interval was

99 ± 18 days for beef cows and 110 ± 43 days for dairy cows, services per conception was 1.2 ± 0.4 for beef and 2.1 ± 1.4 for dairy cows, and pregnancy rate was 91 % for beef cows and 72 % for dairy cows. Dawson reported that approximately 78 % of cows were successfully re-bred. de Kruif et al reported the results of C-section in 128 cows and incisional infection was diagnosed in 15 % of cows; irrigation of the abdominal incision with 10 % povidone-iodine solution during closure of the wound failed to prevent Incisional infection. Success rates and complication of C-section in goats and sheep is limited, but when C-section is performed early in dystocia and sterile technique is used, the re-breeding success rate is expected to be good. Thurley reported that in a study comparing 17 ewes having had a C-section with 17 ewes not having had a C-section, only 2 ewes in each group failed to lamb the next breeding season. The controls ewes produced 19 lambs and the C-section ewes produced 20 lambs. Thus, C-section did not adversely effect either fertility or the number of lambs able to be supported during pregnancy. In a retrospective of 110 C-sections in sheep and goats, only 16 dams were known to have been re-bred, but all 16 conceived and none had a dystocia on the subsequent delivery. This suggests that concerns regarding increase risk of dystocia and the need for repetitive C-sections may be unfounded.

Vaginal and uterine prolapse

Vaginal and uterine prolapse are common problems in cattle, occasional problems in sheep, but more rarely seen in goats. When vaginal prolapse is seen in goats, these occur more frequently in dairy breeds. Acute vaginal prolapse may be seen prepartum or postpartum. Animals suffering prepartum vaginal prolapse should be selected for culling after weaning the current offspring. Dietary factors implicated in vaginal prolapse include poor quality forage, hypocalcemia, high estrogenic content foodstuffs such as legumes and soybean meal, and overcrowding. Individual animal risk factors include obesity, chronic coughing, chronic straining to urinate or defecate, and excessively short tail docking in sheep. Vaginal prolapse may be described using a Grade Scale of I to IV (Table 1). In this grading scale, vaginal prolapse severity and extent of damage is used to assess treatment options.

Acute vaginal prolapse

A plethora of techniques have been described for treatment of acute vaginal prolapse including Buhners suture, boot lace sutures, paravaginal stents, Caslik's suture, rope slings or harnesses in sheep, and indwelling vaginal retainers in sheep. Indwelling retainers and rope slings are purported to have the advantage that kids and lambs may be able to birth around or through the device. However, dystocia is a concern whenever these devices are left in place. Ideally, rope slings or retainers should be removed within a few days of expected parturition. Alternatively, parturition may be induced to allow a shorter interval for close observation or for elective C-section. In small ruminants, suture techniques have a higher risk of tearing through the perineal tissues. When necessary, I have chosen to use a 6 to 12 mm diameter rubber stents to place under mattress sutures. I place 3 to 5 vertical or horizontal matress sutures over a stent that is positioned perpendicular (for vertical mattress) or parallel (for horizontal mattress) to the vulva. All of these techniques are used to maintain position of the vaginal cranial to the vulva and ideally within the vaginal vault. Vaginal vault retention requires replacement of the function of the vestibular sphincter muscles. Thus, the sutures must be placed along the hair-nonhaired margin of the vulva such that the depth of the suture will mimic the effect of the vestibular sphincter muscle. Placement of the sutures too superficially will result in insufficient support of the vaginal tissues and thus persistent or recurrent straining. Persistent straining and recurrent prolapse will result in tearing of the vulva.

Buhner sutures should be placed using a Buhner needle inserted 1-cm incision made approximately at the level of the ischium (4-cm width proximal to the ventral comisure of the vulva) and exiting a 1-cm incision made on midline of the perineum 4-cm dorsal to the dorsal comisure of the vulva. The needle is inserted first, then ¼ inch (6.4-mm) width umbilical tape is inserted in the end of the needle and the suture is pulled back through as the needle is removed. The procedure is repeated on the contralateral side with the needle exiting the same proximal midline perineal incision.

Chronic vaginal prolapse

Although Buhner's suture and other methods of fixation give temporary relief from vaginal prolapse, chronic vaginal prolapse requires more invasive techniques to stabilize the vagina. The Johnson button and Minchev suture techniques are appropriate for vaginal prolapse associated with excessive redundancy of the dorsal vaginal wall. These techniques are traumatic and may result in tearing of the vagina into the abdomen because of chronic straining after surgery or may cause damage to the Sciatic nerve or internal pudendal artery if these structures are not avoided. In these techniques an indwelling needle (Johnson button) or umbilical tape suture (Minchev) are placed from the dorsolateral vaginal wall through the sacrotuberous ligament and through the gluteal musculature. In the case of the Johnson button, large, flat discs are attached to each end to secure the device. With the Minchev suture, rolls of gauze sponges are attached to each end to secure the device. These are left in place for 2 to 6 weeks to allow for extensive fibrous adhesions to form which serve as anchors for the vaginal shelf.

Cervicopexy is appropriate for vaginal prolapse associated with excessive redundancy of the ventral vaginal wall. Cervicopexy can be performed transvaginally or via flank laparotomy. Flank laparotomy offers the best approach for anatomic and permanent fixation because the cervix can be more accurately anchored without interference with the bladder, the suture can be placed without compromise of the cervical lumen, and the suture is permanently placed with little risk of infection. However, cows having chronic

vaginal prolapse are often obese and excessive abdominal fat increases the difficulty of this procedure dramatically. Transvaginal cervicopexy offers the easiest and least invasive surgical approach and is ameanable to field conditions. Two sutures of No 3 vetafil are placed through the cervix (being careful not to penetrate the lumen of the cervix) and are anchored to the prepubic tendon (being careful not to entrap the bladder, urethra, or intestines). Disadvantages of cervicopexy include increased risk of entrapment of the urethra, increased risk of sepsis of the abdomen or cervix, increased risk of compromise of the lumen of the cervix, and suboptimal anatomical positioning.

Vaginoplasty and vaginal resection are effective in the elimination of vaginal prolapse and may be used for either dorsal or ventral wall prolapse, but this procedure prevents the animal from being used in natural service or going through normal parturition. This technique is done with the animal standing with epidural anesthesia. A triangular segment of the dorsal lateral vaginal wall is resected on both sides with the triangles based on dorsal midline. Then, the sides are sutured closed together. The vaginal wall resection should only leave enough room for embryo flushing equipment to be passed through the vagina. Vaginal resection can be performed in chronic vaginal prolapse were vaginal redudency is circumferential such that a complete segment of the vaginal can be removed. Vaginal resection is performed much like rectal amputation. A vaginal speculum is placed into the lumen of the prolapsed vagina and then cross-fixation pins are placed through the vaginal prolapse and tube to stabilize the segment for surgery. The injured portion of the vaginal prolapse is resected and an end-to-end anastomosis performed using No 1 or 2 polyglycolic acid in interrupted suture pattern. Complication sof vaginal resection include stricture, dehiscence, hemorrhage, abscess, and reoccurrence of prolapse.

After surgery, the animal should be rested for 30 days after surgery before insemination or breeding activity is resumed. We only recommend treatment of chronic vaginal prolapse when there is a history of chronic hormonal manipulation. Other vaginal prolapses have a high concern for heritability and these animals should be culled. If the animals is to be made a pet, ovariohysterectomy is recommended. Complications of surgical treatments for vaginal prolapse include reoccurrence, dehiscence, hemorrhage, abscess, damage to vital structures (urethra, sciatic nerve, pudendal artery), and peritonitis.

Long-term prognosis for vaginal prolapse is limited because of culling.

Uterine prolapse

Uterine prolapse in cows is a historic topic, well discussed in scientific veterinary literature and texts, argued at legendary proportion between practitioners, and even referenced in western poetry. The condition occurs very sporadically, is easily recognized, yet sometimes not so easily repaired. Replacing, repairing, and removing the uterus will be discussed in this chapter along with helpful techniques and potential complications. Occasionally the veterinarian encounters situations where manual eversion (iatrogenic prolapse) of the uterus is helpful, particularly for efficiently repairing the traumatized uterus in the field. Therefore, a technique for iatrogenic prolapse will be discussed as well.

Spontaneous uterine prolapse in cows is an occasionally encountered post-parturient complication requiring immediate attention. It almost always happens within 12-24 hours after calving. Occasionally occurrence is delayed until days after calving and complicated by partial cervical involution (closure) creating additive difficulty in replacing the uterus. Cervical involution may necessitate and combination of laparotomy in addition to external reduction. Mid gestation prolapse of the non-gravid uterine horn, with successful management and maintaining a viable pregnancy has been reported.

Uterine prolapse occurs sporadically, with dairy cattle appearing to be more frequently represented than beef cattle. Decreased myometrial tone is a logical predisposing mechanism for occurrence, leading to the proposed risk factors of hypocalcemia, as well as dystocia, causing myometrial fatigue and trauma. Manual extraction of the calf and retained fetal membranes may initiate uterine eversion of the gravid horn(s) followed by complete uterine prolapse after delivery. Uterine prolapse should be regarded as an emergency condition, for one to facilitate replacement, before accumulation of excessive edema, contamination, mucosal trauma and cervical closure occurs. In addition, client communication to restrict movement should be stressed, decreasing the chance of uterine artery rupture or avulsion from the internal iliac leading to fatal hemorrhage. Without timely intervention, the prognosis for life is grave.

Unlike vaginal prolapse, heritability and/or additive individual susceptibility with subsequent pregnancies is not apparent with uterine prolapse. Prognosis for survival is dependent upon timely intervention, parity, calf viability, and lack of secondary metabolic or musculoskeletal disease. A one year study from a large dairy practice in California suggested an incidence of less than 0.1% (200/220,000 cows), and a two-week post-incident survival of 72.4%. A retrospective questionnaire regarding 90 cases of uterine prolapse, and two matched case control herdmates per farm, over a three year period in the UK found only one cow prolapsed a second time. In the same study, survivability was approximately 80% with the 20% mortality resulting from shock (evisceration), blood loss, refractory downer cow syndrome, and humane euthanasia. Jubb et al suggested a 73.5% (50/68) survival rate with only one cow having a history of a previous uterine prolapse. A longer calving to conception interval varied between studies, an additional 10 days to 50days longer. Prognosis for life and future fertility is expected to be good with timely veterinary intervention, and recognition and treatment of secondary complications. In most instances the decision to treat should be cost effective for the producer.

Replacing the prolapsed uterus

Prolapse of the uterus is a diagnosis of observation and physical examination. A large, reddened heavy mass of everted uterus is dramatically visualized, thus exposing placentomes and possibly attached fetal membranes. Treatment should begin with restraining and evaluating the patient for the presence of metabolic and/or musculoskeletal disease and treated as indicated. Animal restraint and cleansing of the exposed endometrium, preferably with hypertonic solutions should be emphasized as priority treatment. Various rope casting restraint methods are described to maintain recumbency and can be applied. In retractable animals chemical restraint may be indicated. Caudal epidural anesthetics prevent straining and facilitate replacement of the uterus, and at higher volumes provide a method of restraint through posterior muscle paralysis. Often, the urethra is positioned in the prolapse such than urination is prevented. By lifting the uterus and allowing urination, additional cow comfort and reduced straining is achieved. This is also a good time to rule out bladder prolapse as an additional complication. It should also be noted that the bladder, and even intestinal viscera, can be contained within the prolapsed uterus. Bladder retro-flexion may persist once the uterus is replaced and result in continued straining by the cow. Ultrasonic evaluation of the pelvic canal for urinary bladder retro-flexion should be performed with persistent straining. When bladder retroversion is present, placement of an indwelling catheter (e.g. Foley catheter) will help maintain normal bladder position until healing has occurred.

Topically applying osmotic agents such as salts and/or sugar has proven beneficial to begin reducing and preventing the edema which rapidly accumulates within the prolapsed tissue. It is also recognized that these products can amplify endometrial trauma. Manual massage during replacement, utilizing ointment with lubrication and emollient properties, is an effective alternative. Attempt to keep the uterus elevated off the ground while cleaning to prevent ongoing contamination. Laundry baskets, kennel grates, and a plethora of fenestrated supportive/containment devices have been used to replace uterine prolapse reduction. The author prefers a ceramic coated adjustable cooking grill grate (20" X 30") when assistance is unavailable, which is easily supported between the cranial thighs/hip of the practitioner and the caudal thighs of the sternal recumbent or standing cow, allowing both hands to be used to work. Evaluate the surface of the exposed endometrium for tearing and perforations and repair at this time if possible. Alternatively, if repair is not possible as in the case of severe necrosis or circumferential lacerations, amputation of the uterus should be considered (see below). Protecting the exposed uterus from further trauma and environmental contamination should be performed by wrapping the uterus in plastic or dampened cloth under compression. Confining the uterus in a wrapped plastic or porous fabric bag will aid in control of the uterus during replacement and prevent handling induced trauma to the friable mucosa. If a compression wrap is applied, do so in a manner which allows sequential removal of portions of the wrap as the uterus is replaced from the base (near vagina) to the apex of the prolapse. Additionally, to reduce handling trauma as well as keep hands warm during cold weather, mittens can be worn while kneading and massaging the uterus during replacement. Begin reducing the prolapse at the base and continue to the apex. Evaluate for complete reduction, passively infuse warm fluid into the uterus to completely reduce the inverted uterine horns. Failure to achieve complete reduction of the prolapse can result in continued straining and uterine necrosis. Remove excess infused fluid by siphoning it out of the uterus after infusion. Administer oxytocin (20-40 IU, IM) to enhance uterine involution.

Full thickness lacerations should be repaired when visualized. It is often suggested that repair can be forgone if lacerations are less than 2 to 3 inches and dorsal (most common), as the defect will close sufficiently with oxytocin therapy and uterine involution. The statement is often implied when tears are noted post live-calf extraction and without uterine prolapse or complications. The author strongly encourages client communication about the risks associated with not repairing uterine lacerations when diagnosed. With a prolapsed uterus, repair is easy to perform with a simple continuous pattern of No. 2 or No. 3 catgut suture. With wide, radiating areas of devitalized or traumatized tissue from the free edges of the laceration, vertical mattress sutures should aid in minimal tension apposition and result in an inverting pattern of the uterus when replaced. Repair should be performed whenever possible, as post partum metritis due to gross contamination and additional trauma has occurred.

Positioning of the cow can facilitate replacement. A very efficient means of positioning is with the cow in sternal recumbency and "frog Legged" (stifles down, pelvic limbs stretch out behind the cow). This position can put the cow at risk for coxofemoral luxation. When available in the field, hip lifters can also help support the tuber coxae or even allow some ventral support of the quadriceps draped over a bale of straw. When replacing the prolapse in the standing animal, a support device (see above) should be utilized. It is best to allow the cow to stand as soon as possible. Application vaginal retention sutures (see vaginal prolapse section) are at the discretion of the individual, but often are not necessary. Vaginal retention sutures may stimulate additional straining by the cow.

Amputation of the prolapsed uterus

Occasionally, extensive calving or environmental trauma has occurred, necessitating a complete ovario-hysterectomy to attempt salvage of the cow for slaughter. Another indication may be when significant delay in treatment has occurred allowing time to cervical involution a preventing reduction of the prolapsed uterus. When deciding on amputation, it is important to remember that the uterine broad ligaments and reproductive tract vasculature are contained within the prolapse and abdominal viscera and urinary bladder may also be enclosed. The near uterine wall should be incised carefully and the inner prolapse evaluated for contained viscera and vasculature. Viscera should be repelled into the abdomen. Visualize and ligate large uterine arteries and veins with large (#3) moistened and doubled catgut suture or umbilical tape.

Differing techniques for removing the uterus have been described. The surgeon may elect to ligate each entire half of the uterus with two complete hemi-circumferential or transfixing sutures using umbilical tape, amputate the uterus distal to the sutures, and replace stump into the pelvic canal. A second technique would be to place a series of overlapping interrupted crushing sutures with catgut for hemostasis of the cut surface, followed by a continuous appositional suture pattern to close the lumen. The latter technique is more time consuming but provides more accurate hemostasis and reconstruction. Another described technique is to circumferentially ligate the prolapsed uterus tightly near the vulva with either surgical tubing or broad suture (umbilical tape) and allow the uterus to slough distal to the suture. The uterus should slough within a week to ten days.

Iatrogenic uterine prolapse

Forced extraction of calves and dystocia can result in uterine tears for various reasons. Laparotomy exposure and "blind" one handed suturing techniques through vaginal access are described elsewhere. One technique for attempting repair of uterine rupture is by manually exteriorizing the uterus to gain visual access of the traumatized area. The cervix must be adequately relaxed for the procedure to be successful, thus limited to within the first few hours (max<12hr) after calving. The cow should be adequately restrained, surgical instruments and suture material ready as well as a uterine support device (see above) or clean plastic drape to support the uterus. The repair should be performed as quickly as possible to prevent accumulation of excessive edema. Most uterine tears are dorsal and just cranial to the cervix, thus complete uterine prolapse may not be necessary.

ß$_2$-adrenergic agonist drugs (betamimetics) have historically been used in veterinary medicine to relax the uterus (tocolysis) for procedures such as facilitating fetal manipulation during assisted vaginal delivery as well as providing more complete exteriorization of the uterus during cesarean section. Examples of these drugs are clenbuterol, isoxsuprine, ritodrine, and epinephrine. Of these pharmaceuticals, only epinephrine is permitted for use in food-producing animals in the USA. A Canadian study indicated successful tocolysis with ritodrine. The author is unaware of the availability, cost or legal limitations with the use of ritodrine in the U.S.A. Personal experience and communication is limited to the use of epinephrine for tocolysis. Epinephrine does have inherent side-effects associated with betamimetics such as altering blood pressure, increasing heart rate, myocardial work and inducing irreversible fatal cardiac arrhythmia. Use as a tocolytic should be weighed on a case by case basis and other options considered.

Most commonly, an intravenous dose of 10ml of 1:1000 epinephrine is used. A dilution with 250ml of sterile saline administered as a constant rate infusion over 10 minutes has been described. A bolus IV administration with 10ml of 1:1000 epinephrine diluted in 50 ml of sterile saline has also been successful without adverse effects in the authors experience. A uterine caruncle, fold of endometrium or placenta is grasped and steady traction applied to evert the uterus. The surgeon should be patient and not overzealous with traction. As progress is made, the surgeon can advance the grip cranial toward the apex of the uterine horn until the uterus is exteriorized. Difficulty in this procedure arise when the weight of the uterus prevents exposure, also it is more successfully done prior to caudal epidural anesthesia allowing the cow to aid expulsion through abdominal press. The defect is then repaired and uterus replaced as within the abdomen.

Table 1. Clinical grading scale for vaginal prolapse in cattle.

Grade	Description	Relevance	Treatment
I	Intermittent prolapse of vagina; most commonly when lying down.	Likely to progress to Grade II if not treated.	Temporary retaining suture; cull after calving or perform permanent fixation technique if embryo flush cow.
II	Continuous prolapse of vagina +/- urinary bladder retroflexed.	Urinary bladder involvement (common) can obstruct urination or cause persistent straining.	Temporary retaining suture; cull after calving or perform permanent fixation technique if embryo flush cow.
III	Continuous prolapse of vagina, urinary bladder and cervix (external os visible).	Can cause compromise to urine outflow and ureters. Should be treated quickly to prevent life threatening injury.	Perform permanent fixation technique if embryo flush cow. Induce parturition or perform elective C-section if commercial cow.
IV	Grade II or III with trauma, infection, and/or necrosis of vaginal wall. a. Subacute such that replacement into vaginal vault is possible. b. Chronic with fibrosis such that the vagina can not be replaced.	Grade IV a. repair laceration, debride wounds, treat infection and replace into vaginal vault. Grade IV b. Requires elective C-section or vaginal resection.	Perform permanent fixation technique if embryo flush cow. Induce parturition or perform elective C-section if commercial cow.

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