Review Report

A review of small ruminant Cesarean section: case selection, surgical techniques, care of the neonates, and postoperative care of the dam

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Abstract

Cesarean section is an important life-saving surgical procedure frequently performed by small ruminant practitioners. Knowledge of normal parturition and indications for obstetrical intervention are necessary for successful outcomes. If a doe or ewe is observed in active labor for more than an hour without signs of progression toward delivery of a fetus, obstetrical examination is indicated to guide appropriate interventions. It is often possible to relieve a dystocia without surgical intervention if the cervix is adequately dilated and the dam's pelvis is of sufficient size to allow manipulation of the fetus. If vaginal delivery cannot be performed safely, a Cesarean section or fetotomy is indicated. The surgery is generally performed with sedation and local anesthesia, with a lumbosacral epidural preferred by the authors. The dam may be positioned in right lateral recumbency, standing, or dorsal recumbency, based on the surgeon's preference and specifics of the case. The abdomen is entered routinely, the gravid uterus identified, and gently exteriorized through the abdominal incision. A hysterotomy incision is made over the greater curvature of the uterus to allow removal of the fetus(es). The uterus is closed with absorbable suture using an inverting pattern. The abdominal incision is closed routinely. Systemic antibiotics, ecbolic agents, and analgesic agents are recommended for the dam postoperatively. Survival of the dam is reported at 81–99% with post-surgical complications encountered in 33–77% of cases. Females may be retained for future breeding following surgery, with 84–100% of females reported to become pregnant in the subsequent breeding season.

Keywords: Hysterotomy, ewe, doe, dystocia, C-section

Parturition

Parturition is divided into three stages. Stage one, the preparatory stage, is characterized by the initiation of myometrial contractions, and lasts from 2 to 12 hours in small ruminants.[1] During this stage, the female will usually leave the group, appear restless, and may urinate frequently. Cervical relaxation occurs during stage one and passage of the cervical plug may be observed.

Stage two labor begins when a fetus enters the pelvic portion of the reproductive tract and is generally accompanied by forceful abdominal contractions, rupture of the chorioallantoic membranes, and expulsion of the allantoic fluid. Stage two ends when the last fetus is expelled by forceful abdominal muscle contractions of the dam.[2] During stage two, if the fetus is in cranial longitudinal presentation with forelimbs extended, the amniotic membrane will protrude from the vulva and rupture, followed shortly by the appearance of fetal forelimbs and head. Caudal longitudinal presentation is not uncommon and may be considered normal if both hind limbs are extended and delivery progresses normally.[3] When multiple fetuses are present, deliveries may occur in quick succession or the female may rest briefly in between delivery of subsequent fetuses.[4]

The third stage of labor begins immediately after delivery of the final fetus and concludes with passage of the fetal membranes.[2] Expulsion of the membranes usually occurs within four hours of normal parturition.[2] If delivery was uncomplicated, retention of fetal membranes is of little concern until 12–18 hours post-partum.[4] Lochia, the brown-red discharge from the involuting postpartum uterus, may be present for up to three weeks.[5,6]

Dystocia

Dystocia is defined as slow or difficult labor.[7] Dystocia is present when labor is prolonged, interrupted, or when delivery of the fetus(es) cannot be completed in a timely manner without assistance. Any female that fails to progress normally through the stages of parturition, either from stage one to stage two or

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during stage two labor, should be examined. If a doe or ewe is in active labor, without producing a fetus, for longer than thirty minutes to one hour, assessment and obstetrical intervention is indicated.[8]

Dystocia in small ruminants is relatively uncommon. Historically, in well managed herds less than 5% of births require assistance.[3] Current normal dystocia rates in large herds has not been reported. The primary causes of dystocia differ between sheep and goats. In ewes, insufficient cervical dilation is reported as the cause of dystocia in 14–44% of cases presented.[9–12] In does, feto-pelvic disproportions reportedly account for 23–52% of dystocia cases.[11,13,14] Other factors identified as causes of dystocia include uterine torsion, vaginal prolapse, fetal malformation or malposition, and metabolic disorders.[9] A significant increase in the occurrence of dystocia has been reported in ewes when diagnosed with pregnancy toxemia.[15]

Dystocia can often be relieved by trans-vaginal manipulation of the fetus. Manipulation requires that the dam's pelvis be large enough to admit a hand for obstetrical assistance and the cervix be sufficiently dilated to allow for correction of errors in presentation, position, or posture.[16] Epidural anesthesia administration prior to vaginal palpation in small ruminants is likely to decrease the likelihood of uterine, cervical, or vaginal tears occurring by reducing straining by the dam.[17–19]

Successful resolution of dystocia and delivery of the fetus(es) occur frequently on farm settings. Cases not easily resolved on farm require further interventions such as fetotomy, Cesarean Section (C-section), or euthanasia. All methods can be performed on farm, or preferentially in a hospital setting.[4] In the cases of small ruminant dystocia presented to referral facilities, 43–95% required C-section.[12–14,20,21]

If a fetotomy is to be attempted, it is recommended to perform a subcutaneous fetotomy instead of a percutaneous approach.[3] A subcutaneous fetotomy is safer for the dam since instruments are not inserted into the birth canal potentially damaging friable maternal tissues.[2,3] This type of fetotomy is performed by exteriorizing a fetal limb and making a skin incision around the limb, preferably above the carpus.[22] The skin incision is continued up the medial side of the fetal limb but it is not necessary to extend the incision so far as to insert the blade into the vagina.[22] The practitioner's hand is used to undermine the skin to the level of the shoulder blade; the muscular and tendinous attachments are broken down, and the limb is pulled free.[2] Decapitation and neck amputation are easily performed in a dead and emphysematous fetus to allow for further extraction of the fetal body.[4] It is an important consideration when performing small ruminant obstetrical intervention that many causes of abortion may be zoonotic and personal protective equipment is recommended.[4]

Anesthesia

Anesthesia for C-section procedures is case and surgeon dependent, but generally utilizes a combination of sedation and local or regional anesthesia. Sacrococcygeal or lumbosacral epidural anesthesia is advantageous as it can induce recumbency while providing anesthesia to the paralumbar fossa or abdominal midline.[19] The proximal paravertebral, distal paravertebral, line block, or inverted L block can also be used for anesthetizing the paralumbar fossa. A line block is the most appropriate technique for the ventral midline celiotomy approach of performing a C-section. Patient condition, demeanor, and surgical approach dictates the choices for sedative agents or uncommonly the need for general anesthesia.

At the authors' hospital, administration of a lumbosacral epidural is commonly the first step in surgical preparation for small ruminants undergoing Cesarean section. Epidurals in sheep and goats can be performed as in cattle at the sacrococcygeal space (S5-Co1) but are also easily performed and reliably effective when administered at the lumbosacral space.[19] Following sterile preparation, the depression overlying the lumbosacral space is identified by palpation on midline from along a transverse line drawn from the wings of the ilium and identifying the dorsal spinous processes of the last lumbar vertebra and the first sacral vertebra. An 18- or 20-gauge 25 millimeter (mm) needle is usually sufficient to administer 1–2 milliliters (mL) per 10 kilograms (kg) of 2% lidocaine (VetOne®, MWI, Boise, ID) into the epidural space using the hanging drop technique (Figure 1).[23] A longer needle, such as

Figure 1. Palpation of the landmarks for a lumbosacral epidural.

a 20-gauge 75 mm or spinal needle, may be required in larger does and ewes.[24] Epidural administration of 2% lidocaine at this dose and volume will provide analgesia of the caudal abdomen to the level of the umbilicus sufficient for either the flank or ventral midline approach; the animal will become recumbent.[24–26] Should the subarachnoid space be penetrated while attempting to place the needle for administration of the lumbosacral epidural, flow of spinal fluid from the needle will be observed. In that instance, the needle may be either repositioned, or half of the dose originally planned for epidural anesthesia can be safely administered into the subarachnoid space.[19] Other reports describe using xylazine (AnaSed® injection, Akorn, Lake Forest, IL) at 0.07 milligram/ kilogram (mg/kg) with or without lidocaine to extend the duration of epidural anesthesia.[24]

If the lumbosacral epidural fails to provide adequate analgesia for surgery, paralumbar fossa anesthesia can be supplemented with either an inverted L block or a line block. Alternatively, distal and proximal paravertebral blocks have been described for small ruminants using smaller volumes of lidocaine compared to cattle.[25] Two percent lidocaine can be diluted 1:1 using normal saline to increase the volume for distribution of the local anesthetic agent. A line block is commonly chosen by some practitioners for the ventral midline approach and inhalant isoflurane can be used to maintain anesthetic depth if necessary.

Small ruminant practitioners should be aware that sheep and goats are more sensitive to lidocaine toxicity compared to cattle. The reported safe doses of lidocaine range from 4 to 10 mg/kg.[2,24,25,27,28] At the author's hospital, maximum levels of 2% lidocaine used in small ruminants is 6 mg/kg.[4] Convulsions due to IV administration of lidocaine have been reported to occur as low as 3.7 mg/kg in adult ewes, but toxic effects were not apparent when administered subcutaneously until an average of 12 mg/kg in goat kids.[29,30] An example case of a local anesthetic protocol for a 25 kg doe, of which the maximum safe dose of lidocaine would be 7.5 mL (150 mg), would be to administer 2.5 mL of 2% lidocaine as a lumbosacral epidural and use 5 mL of 2% lidocaine diluted 1:1 with normal saline to allow 10 mL of solution to be used as a line block or regional block.

In addition to local and regional anesthesia, some level of sedation is advised. Midazolam (Midazolam Hydrochloride, West-Ward, Eatontown, NJ) is commonly used beginning at 0.2 mg/kg and increasing if necessary to 0.4 mg/kg.[31] Xylazine is usually not recommended as a first choice because fetal hypoxemia, respiratory acidosis, increased uterine contractions, and decreased uterine blood flow have been associated with its use.[32] If necessary, xylazine may be used at low doses (0.01–0.05 mg/kg) after removing any live fetuses.[31] Placement of a jugular catheter for venous access facilitates drug re-dosing and allows for intravenous fluid support during and following surgery.

Surgical procedure

C-section in the small ruminant is performed utilizing a left paralumbar incision or a ventral midline approach. The surgical approach chosen must include consideration of the health of the dam, the risk to the fetus(es), and the availability of support personnel. The best visualization and exposure of the uterus is possible with a ventral midline approach and is preferred when uterine contents may be contaminated.[24] When ruminants are positioned in dorsal recumbency, respiratory compromise from abdominal pressure on the diaphragm can occur. Some clinicians prefer general anesthesia and endotracheal intubation when performing a ventral midline approach to allow for controlled ventilation.[16] A paralumbar fossa approach allows adequate visualization for most cases with less compromise to patient ventilation.[2] Mild respiratory compromise can be minimized by providing flow-by nasal oxygen and monitoring for cyanosis of the mucous membranes.

Flank approach

The left paralumbar fossa is the most common surgical approach chosen.[4,33] In this approach, the patient is positioned in modified right lateral recumbency tilted at a ~30-degree angle toward the surgeon. In a field setting, if patient demeanor and systemic stability allows, the patient can be restrained in a standing position. Often, a show trimming stand placed against a wall is used to restrain the dam and allows a convenient operating height for the surgeon.[34] The left flank is surgically clipped and prepped. A vertical or slightly oblique 15–25 centimeter (cm) skin incision is made beginning approximately 10 cm below the transverse processes of the lumbar vertebrae centered in the paralumbar fossa (Figure 2).[24] The skin and the cutaneous trunci muscle are incised sharply. Occasionally, if a small fetus is expected, the muscles can be 'gridded' or parted along the fiber plane, but this approach reduces the degree of surgical exposure and is seldom used by these authors.[35] In routine cases, the external and internal abdominal oblique muscles are incised with either a scalpel blade or scissors (Figure 3). Caution must be utilized on incision of the transversus abdominis muscle and peritoneum to avoid accidental incision of the rumen due to its proximity to the incision line. Any accidental incision into

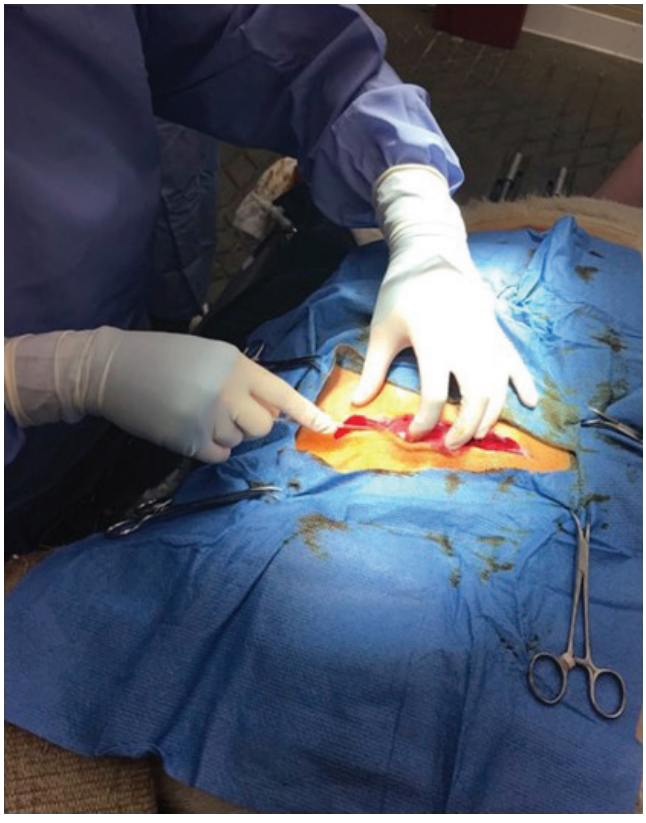

Figure 2. Left flank approach paralumbar fossa incision.

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Figure 3. Incision of the transversus abdominis muscle and peritoneum.

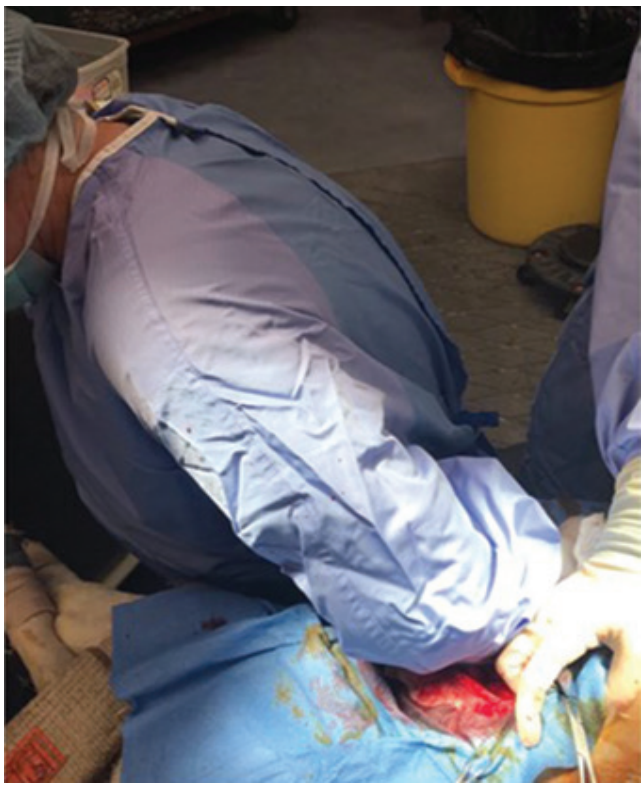

Figure 4. After the rumen has been moved cranially, the uterus is grasped and brought to the abdominal incision.

Figure 5. A fetal limb is grasped through the uterine wall to aid in exteriorization of the organ.

the rumen should be closed first with a simple continuous pattern.[35] Second, after copious lavage of the region and changing of surgical gloves, the rumen incision is oversewn utilizing absorbable suture in a Cushing pattern.[35] Opening and entering of the peritoneum is associated with the sound of air being drawn into the abdomen due to the negative pressure in the abdomen. Sheep and large-breed goats may have abundant retroperitoneal fat that complicates the surgical approach.[4]

After entering the abdomen, the rumen is moved cranially to facilitate access to the uterus (Figure 4). Carefully grasping a fetal limb through the uterine wall allows the surgeon to draw the uterus to the incision and gently exteriorize a uterine horn containing a fetus (Figure 5).[16] Exteriorization of the uterus can be facilitated with a tocolytic dose of epinephrine (Epinephrine 1:1000, VetOne, Boise, ID) administered at 0.5–1 mg (0.5–1 mL of a 1:1000 solution) intramuscularly depending on the size of the ewe or doe.[2] Following exteriorization of the uterus, the surgeon can isolate the organ using sterile towels or lap sponges and protect the abdominal cavity from contamination following hysterotomy and extraction of the fetus(es) (Figure 6).

When possible, the hysterotomy incision is best made over the greater curvature of the uterus to minimize hemorrhage (Figures 7 & 8).[36] The incision can be made directly over a fetal limb or a fetal head.[4] To minimize uncontrolled uterine tears, the hysterotomy incision should be long enough to allow for delivery of the largest portion of the fetus. Following removal of the first fetus, the surgeon's hand is then inserted into the hysterotomy site to retrieve the remaining fetuses. The surgeon's hand can be directed caudally toward the uterine bifurcation and into the contralateral horn to allow retrieval of all

Figure 6. A fetal limb is grasped through the uterine wall to aid in exteriorization of the organ.

Figure 7. Hysterotomy is made over the greater curvature of the uterine horn.

other fetuses.[16] In some cases, a second hysterotomy may be required to reach a fetus in the opposite uterine horn. Abdominal contamination is inevitable in many C-section cases but all precautions should be taken to mitigate. The hysterotomy site should be kept fully exteriorized and isolated with sterile towels or lap sponges to ensure uterine fluid does not drain back into the peritoneal cavity. This is especially important if a dead fetus was removed at surgery (Figure 9).

Figure 8. The incision is made long enough for the fetus to be extracted without uncontrolled uterine tearing occurring.

Figure 9. Maintenance of exteriorization of the hysterotomy site to prevent abdominal contamination.

Unattached portions of the fetal membranes may be trimmed to facilitate uterine closure, but cotyledonary

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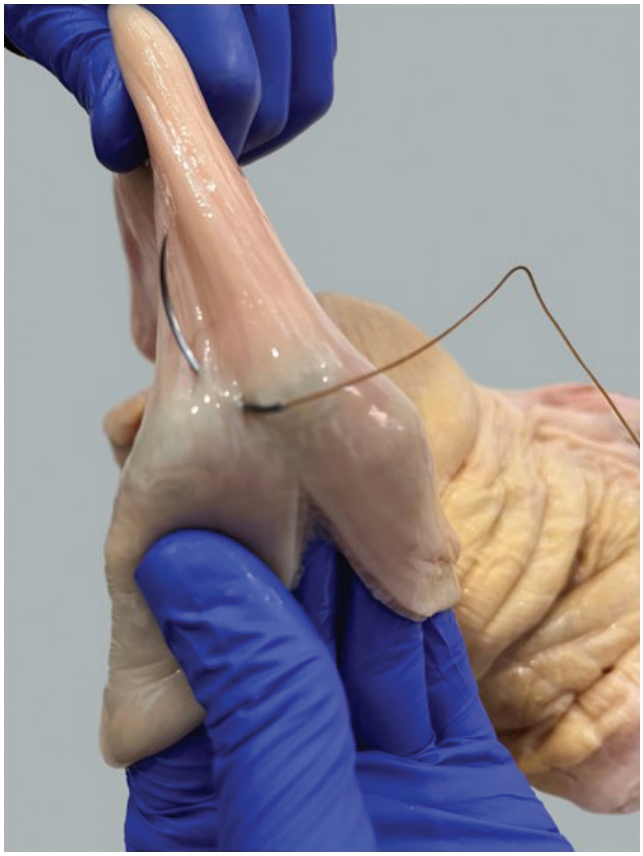

Figure 10. Beginning knot of Utrecht pattern as described by Roberson, 2004.[48]

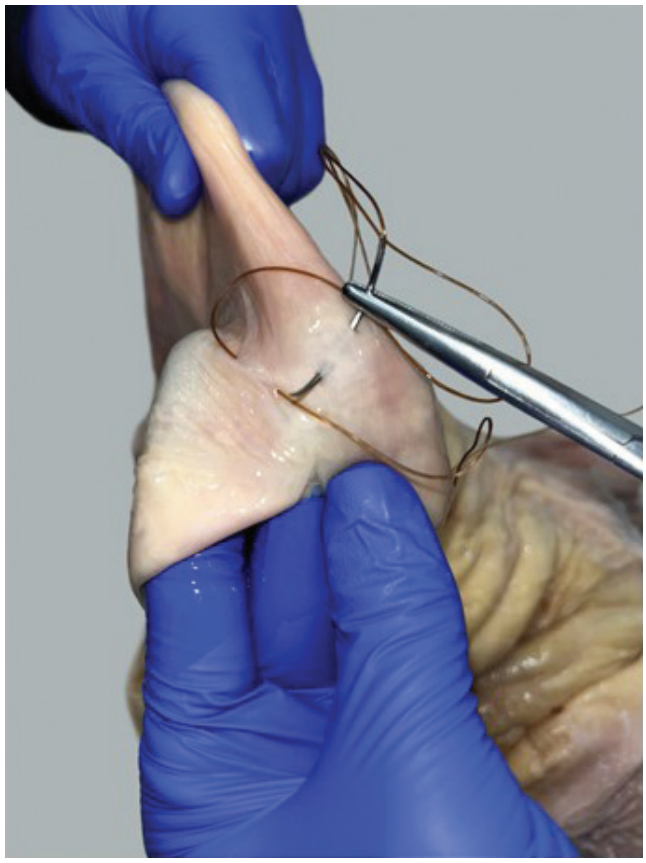

Figure 11. Beginning knot of Utrecht pattern as described by Roberson, 2004.[48]

attachments should not be forcefully detached.[2] The hysterotomy site is closed using a partial thickness inverting suture pattern, such as the Utrecht, Cushing, or Lembert to achieve a tight serosa to serosa seal (Figures 10–20).[37] Sutures should not penetrate the uterine lumen. Absorbable suture of size 0 or 1 on an atraumatic taper needle should be used; Poliglecaprone 25 (Monocryl™, Ethicon), Polydioxanone (PDS™, Ethicon), or Chromic Gut (Chromic Gut, Ethicon) are common choices (Figure 21). A double-layer closure ("over-sew") of the hysterotomy site is indicated if the uterine contents were severely contaminated or if the uterine wall is friable (Figure 22). The use of intrauterine boluses or antibiotics is controversial and not recommended due to the risk of endometrial damage occurring.[4] Following initial closure, the uterus should be carefully examined for previously undetected uterine tears and excessive hemorrhage.

After uterine closure, the uterine serosal surface should be lavaged with sterile isotonic fluid to remove large blood clots and debris. Repeated abdominal lavage and suction may be indicated if extrauterine contamination of the peritoneal cavity occurred. Sodium carboxymethylcellulose in a 1% solution (Carboxymethylcellulose Sodium Salt, High Viscosity, MP Biomedical LLC, Solon, OH) is sometimes instilled into the abdomen to decrease the formation of adhesions.[38,39] Infusion doses range from 30 mL total up to 14 mL/kg.[38,39] An alternative to sodium carboxymethylcellulose is to use 30 mL of glycerol (Glycerin U.S.P. 99.5%, Humco Labs, Texarkana, TX) in 1 liter (L) of saline to make a 3% solution.[37]

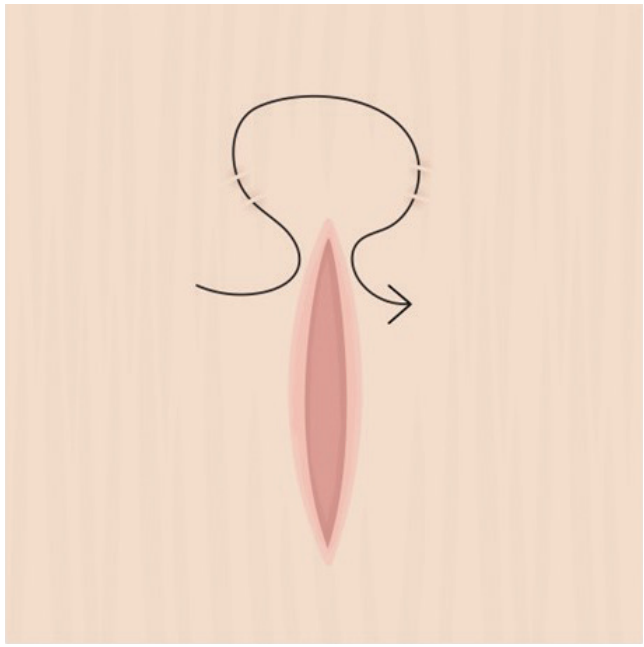

Figure 12. Beginning knot of Utrecht pattern as described by Roberson, 2004.[48]

The abdominal incision through the paralumbar fossa should be closed in three layers: 1) the peritoneum and transversus abdominis muscle, 2) the internal and external abdominal

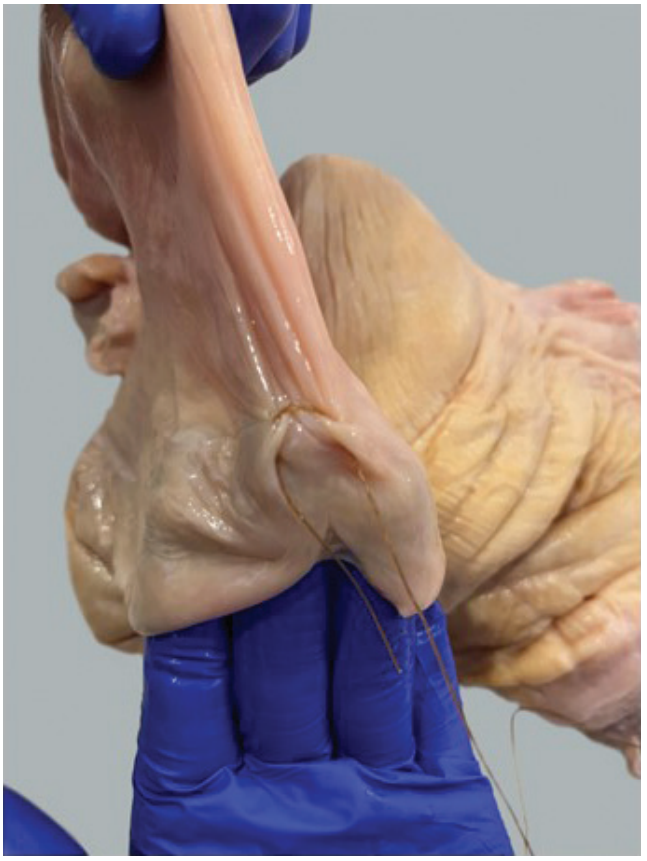

Figure 13. Beginning knot of Utrecht pattern as described by Roberson, 2004.[48]

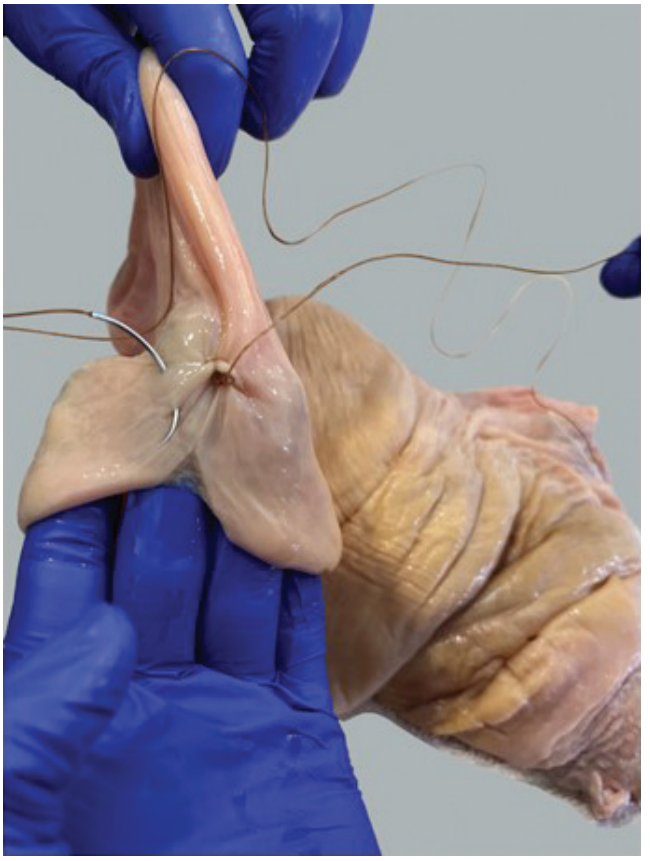

Figure 14. Utrecht suture pattern for uterine closure.

oblique muscles with the subcutaneous fat, and 3) skin.[16] Size 1 or 2 absorbable suture, such as coated Polyglactin 910 (Vicryl, Ethicon), Polydioxanone (PDS™, Ethicon), or Chromic Gut (Chromic Gut, Ethicon), in a continuous pattern is used for the peritoneum and muscle layers. Size 0 or 1 non-absorbable suture in a Ford-interlocking pattern is frequently used for skin closure.

Ventral midline approach

The ventral midline surgical approach provides better uterine exposure than the more commonly used left paralumbar fossa approach.[16] This approach is used most when severe contamination of uterine contents is suspected. The patient is positioned in dorsal recumbency and the ventral abdomen from the umbilicus to cranial udder is surgically clipped and prepped. A skin incision is made just cranial to the udder and extended cranially 20–25 cm.[2,24] Identification of the subcutaneous abdominal veins (milk vein) is imperative as these veins are large in late pregnancy.[24,40] The subcutaneous tissue is bluntly dissected until the linea alba is identified. The abdominal wall is tented, and a stab incision is made through the linea alba taking care to avoid incising any underlying viscera. The incision can then be safely extended using Mayo scissors.

Upon entering the abdomen, the greater omentum and abdominal viscera will need to be moved cranially to allow access to the uterus.[24] A fetal limb can be gently grasped through the uterine wall and the entire organ exteriorized from the abdomen and isolated using lap sponges or sterile towels. As discussed above, the use of a tocolytic dose of epinephrine will facilitate uterine exteriorization. After the uterus is packed off to prevent abdominal contamination, an incision is made over the greater curvature of the uterus to minimize hemorrhage. The uterus should be kept exteriorized and uterine contents drained away from the incision line if contaminated uterine contents are present. The uterus is closed as described for the flank approach utilizing an inverting pattern with absorbable suture on an atraumatic needle. Once closed, the uterus is lavaged, cleaned of any blood clots and debris, and examined extensively for tears. Abdominal lavage as described for the paralumbar approach is often advisable if labor has been protracted or peritoneal contamination is suspected.

The ventral abdomen is closed using size 0, 1, or 2 absorbable suture with an atraumatic needle in a routine method preferred by the surgeon. Commonly, a simple continuous pattern utilizing Polyglactin 910 (Vicryl, Ethicon) is chosen. Closure must be secure enough to allow healing of the linea alba to prevent herniation of abdominal contents. The subcutaneous space is closed using absorbable suture in a continuous pattern. Size 1 or 3 non-absorbable suture in a Ford interlocking pattern or simple interrupted suture pattern is used for skin closure.

Post-partum care

Postoperatively, patient status should be assessed, and dehydration and electrolyte abnormalities addressed. Post-surgical antibiotics, especially if there was a dead fetus, are

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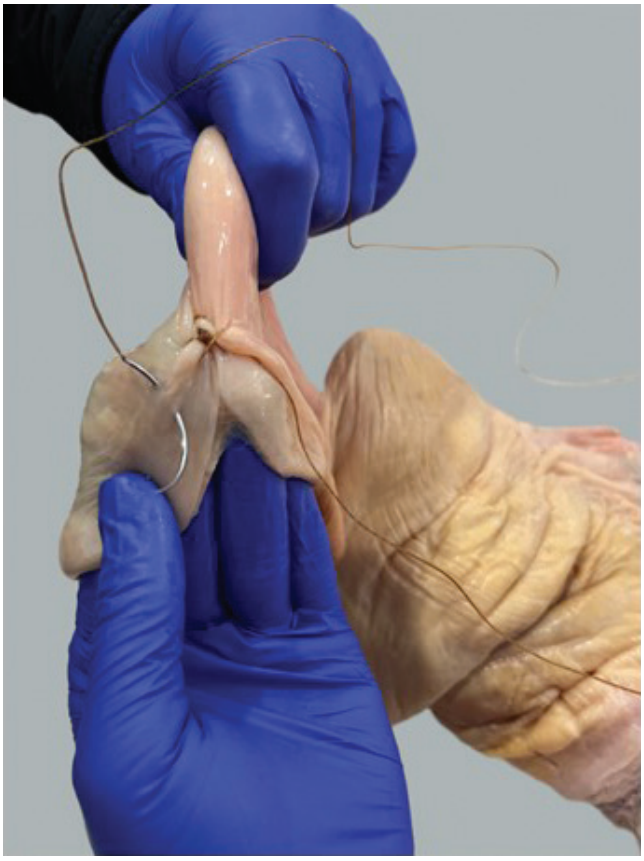

Figure 15. Utrecht suture pattern for uterine closure.

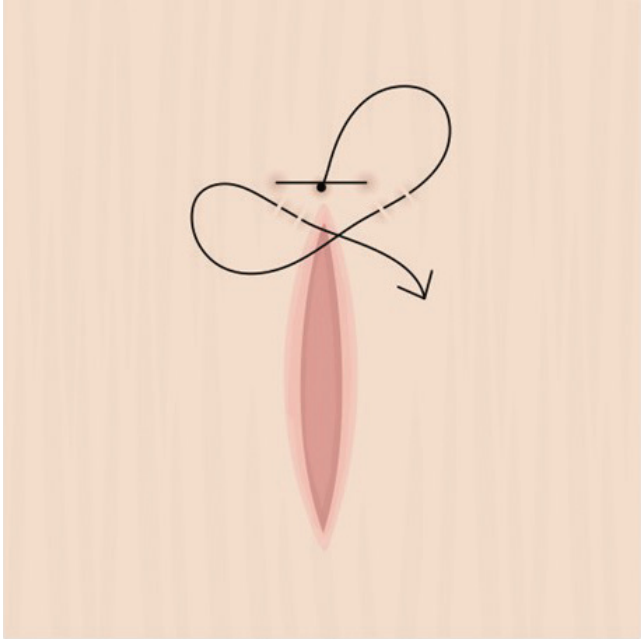

Figure 16. Utrecht suture pattern for uterine closure.

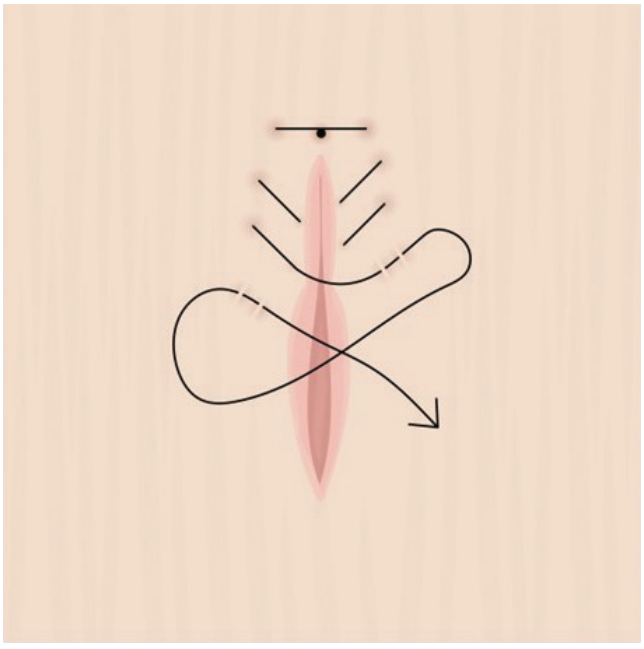

Figure 17. Utrecht suture pattern for uterine closure.

Figure 18. Ending knot of Utrecht as described by Roberson, 2004.[48]

frequently necessary. Currently no antibiotics are labeled for the post-operative treatment for food producing animals and regulations for extra-label drug use must be followed. Commonly used antibiotics at the author's hospital include ceftiofur sodium (Naxcel®, Zoetis, Kalamazoo, MI) at 2–4 mg/kg intravenously (IV) or intramuscularly (IM) every 12–24 hours, oxytetracycline (Liquamycin®, Zoetis, Kalamazoo, MI) at 20 mg/kg IM or subcutaneously (SQ)

Figure 19. Ending knot of Utrecht as described by Roberson, 2004.[48]

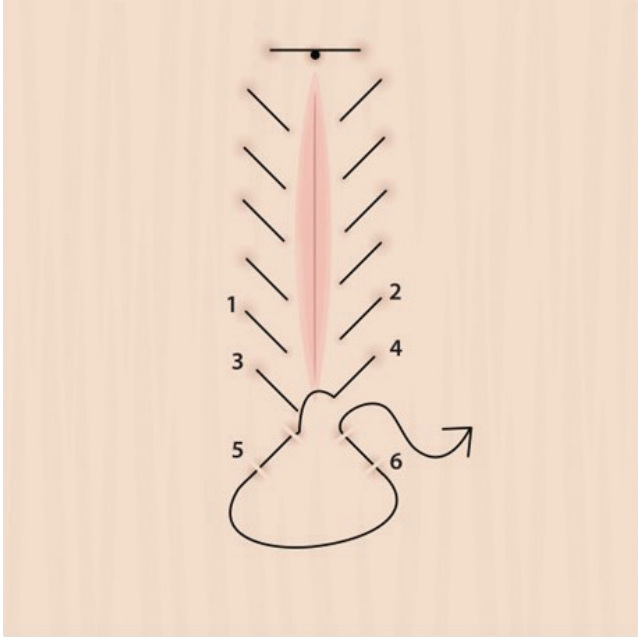

Figure 20. Ending knot of Utrecht as described by Roberson, 2004.[48]

every 24–48 hours, or florfenicol (Nuflor®, Merck Animal Health, Rahway, NJ) at 40 mg/kg SQ once.[41]

Figure 21. Uterus after a Utrecht closure has been placed.

Post-partum care of the dam should include pain management. As mentioned for post-operative antibiotics, no drugs have Food and Drug Administration approval for this use, and appropriate precautions for extra-label drug use must be a consideration. Non-steroidal anti-inflammatories (NSAID) used include flunixin meglumine (Banamine®, Intervet/ Merck, Madison, NJ) at 1.1 mg/kg IV every 12–24 hours for three days or meloxicam at 1 mg/kg orally every 24 hours.[41] Meloxicam may be useful if the patient is not maintained in hospital.[41] Opioids such as butorphanol (Torbugesic®, Zoetis, Kalamazoo, MI) at 0.1 mg/kg SQ every 6–8 hours or morphine (morphine sulphate injection, Hikma, Eatontown, NJ) at 0.1–0.5 mg/kg SQ every 6–8 hours may be administered for additional pain management for up to 48 hours.[41] Most patients are standing and eating quickly after surgical recovery and non-steroidal anti-inflammatories are often discontinued three days after surgery, depending on assessment of the dam's pain level.

Passage of fetal membranes should occur within 12 hours after a normal delivery. After a C-section is performed, passage of the necrotic membranes is imperative for hysterotomy site healing. Oxytocin (VetOne, Boise, ID) is used as an ecbolic agent at 5–10 international units (IU) IM, SQ, or IV up to every 3 hours until the fetal membranes have passed.[2,16] Prompt management of retained fetal membranes will reduce the likelihood of other more severe complications occurring.

Surgical complications

Following emergency C-section postsurgical complications reportedly occur in 33–77% of cases.[9,12,13] Of all

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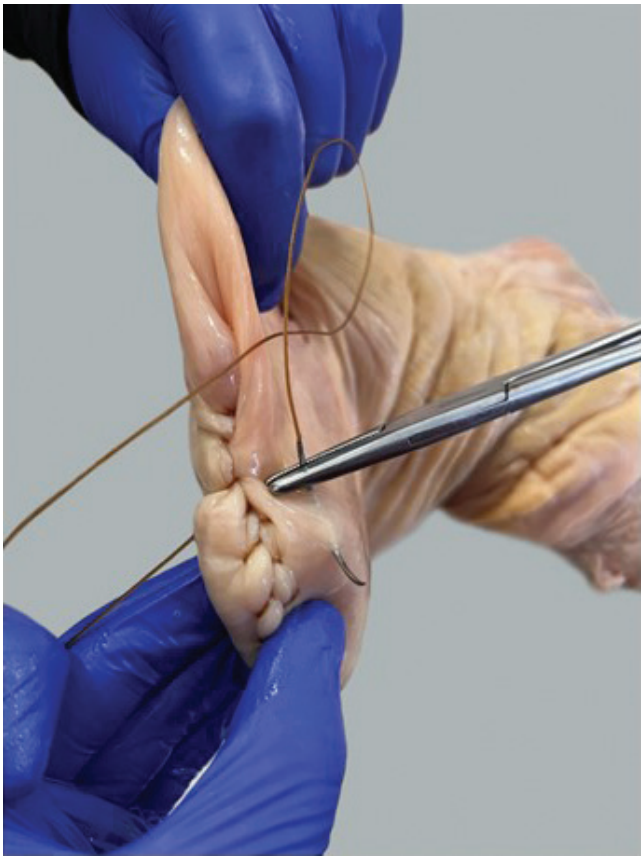

Figure 22. Second layer uterine closure utilizing a modified Cushing pattern.

complications, retained fetal membranes is reported most commonly at 13–45%.[9,13] Other postoperative complications include delayed incisional healing, incisional dehiscence, vaginal prolapse, anorexia, and anemia.[13] The preoperative state of the dam following prolonged dystocia impacts the likelihood of developing complications.[9] In one study comparing the outcome of ewes following vaginal delivery or elective C-section, only 8% of the ewes subjected to C-section developed postoperative complications.[34] Another study reported that the development of complications was higher in cases that did not receive postoperative antibiotics.[13]

Reports of dam survival postoperatively are high at 81–99%.[9,12–14,20,34] Historically, a difference has been observed in dam survivability if live or autolyzed fetuses were present at the time of surgery. Dams with live fetuses had a 98% survival rate and dams with autolyzed fetuses present had a survival rate of 57%.[10] This difference in survival rate has not been duplicated in other reports.[9,12,20,34] Ewes that present with a history of concurrent disorders, such as vaginal prolapse or pregnancy toxemia, are reported to have a C-section survival rate of 68.5% compared to ewes with no concurrent disorders which had a survival rate of 96.2%.[9] In one report, all females presenting with pregnancy toxemia died.[13] Other reports revealed a 70%–75% mortality rate for does diagnosed with pregnancy toxemia.[42,43] For ewes that underwent C-section, if presenting with a history of repeated vaginal prolapse, or had a vaginal prolapse at the time of presentation, there was a 10-fold increased likelihood of a C-section having to be performed.[10] For ewes undergoing C-section, there was a significant association with survival when presenting with no vaginal prolapse.[10]

Future fertility

Of interest to producers is the future fertility of the dam after a C-section. In retrospective studies, small numbers have been followed to re-breeding with reports of 84–100% of postsurgical cases achieving pregnancy in the next breeding season.[9,13] In a report comparing vaginal delivery and elective C-section, there was no difference in pregnancy rates between ewes that vaginally delivered or underwent C-section the prior year, with a pregnancy rate of 89% in both groups.[34]

Neonatal care

Reported neonate survival rates range from 42 to 82% postoperatively.[9,12–14] Duration of labor for greater than 12 hours was significantly associated with fetal mortality.[9] In a study comparing vaginally delivered lambs versus elective C-section delivered lambs, there was no postoperative or long term differences between survivability of the lambs, emphasizing the need for timely intervention of dystocia incidences.[34] In a recent study comparing kid survival rates after delivery from a C-section performed under sedation or under general anesthesia, kid survival rate was significantly higher in the sedation (90.4%) group compared to the general anesthesia group (66.7%).[26]

When neonates are first delivered from the uterus, they may need resuscitation depending on the duration of labor and the amount or type of anesthetic administered to the dam. Oxygen supplementation should be available. Depending on the dose and type of sedation administered to the dam, a reversal agent can be given to the neonate. Midazolam is reversed using flumazenil (Baxter Healthcare, Deerfield, IL) at 0.01 to 0.02 mg/kg intravenously.[44] The effects of xylazine are reversed using atipamazole hydrochloride (Antisedan®, Zoetis Inc, Kalamazoo, MI) at 0.1 mg/kg intramuscularly.[31]

Neonates should receive 50 mL/kg of colostrum within the first two hours after birth and a total of 200 mL/kg in the first 24 hours.[4] Commercial small ruminant colostrum replacer products are preferred if available, but bovine colostrum replacers may be used for adequate IgG transfer.[45] Total protein levels are assessed one to two days after birth for diagnosis in transfer of passive immunity.[46] Total protein values of 5.1 to 5.4 grams/ deciliter or below have been correlated to failure in the transfer of passive immunity in kids.[46,47]

Conclusion

Cesarean section is commonly performed in small ruminants and can be necessary to ensure the viability of both the dam and neonate(s). A preoperative assessment of the dam is always necessary, and the welfare of the ewe/doe and the lamb(s)/kid(s) must guide the choice of technique and post-operative management. Mastery of this procedure is important for any veterinarian that treats small ruminants.

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