Urogenital surgery in camelids

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Abstract

Surgical interventions on the urogenital system are some of the most common procedures performed in veterinary practice. The present paper describes indications, techniques, possible complications and postoperative care of urogenital surgeries in camelids. Potential complications are discussed, based on retrospective analysis of clinical cases seen by the authors over the past 28 years of theriogenology practice. Although not part of the urogenital system, excision of the soft palate and rectal prolapse in camels are also discussed, as these disorders are related to reproductive activity in this species.

Keywords: Cesarean section, ovariectomy, laparoscopy, cryptorchydectomy, prolapse

Introduction

Urogenital surgeries are undoubtedly among the most commonly performed procedures in veterinary practice. They can be divided into 3 general categories: elective surgeries, surgeries to reestablish reproductive function, and emergency surgeries. Elective surgeries are primarily used to eliminate reproductive function (castration, ovariectomy), to prepare teaser animals (vasectomy), or to perform advanced reproductive techniques. Surgeries to restore or preserve normal reproductive function include, unilateral gonadectomy, and repair of the reproductive tract anatomy. Emergency surgeries in the female include cesarean section, laparotomy, and vaginal and uterine prolapse replacement. Emergency surgeries in the male, include primarily unilateral castration of an injured testis, preputial disorders, and urolithiasis. Excision of the soft palate is a frequent procedure in the dromedary camel. The present paper describes the indications, postoperative care and possible complications associated with reproductive surgeries based on the authors' experience. Some of the surgical techniques have been described elsewhere and are not detailed in this paper.

General consideration

The primary consideration prior to surgery is the approach to analgesia and anesthesia. These protocols are generally dictated by the type of surgery, species and the overall health of the patient. In the field, most elective surgeries are performed using a combination of chemical and physical restraint (Table 1). Deep sedation and field anesthesia may be obtained with higher doses of the same drugs. Heavier sedation and regional or local anesthesia is excellent for more involved surgeries, such as cryptorchidectomy and flank cesarean section. General anesthesia is mostly indicated in advanced techniques such as midline cesarean section, cystotomy, and laparoscopy. In the field, general anesthesia may be obtained with injectable anesthetics. In a hospital setting, general anesthesia is preferably induced with injectable anesthetics and maintained with gas (e.g. isoflurane in oxygen). Details are summarized in Table 1.

In nonemergency surgeries, feed should be withheld for 24 - 48 hours prior and water for 12 - 24 hours prior, depending on the size of the animal. Broad spectrum antibiotics and tetanus toxoid should be administered prior to surgery.

Postoperative pain management may include butorphanol tartrate (0.05 - 0.1 mg/kg IM), flunixin meglumine (2.2 mg/kg), morphine (0.1- 0.25 mg/kg IM, every 24 hours) or meloxicam (1 mg/kg, every 48 - 72 hours in alpacas and llamas, 0.5 mg/kg, orally every 48 - 72 hours in camels). It is extremely important to consider the degree of hydration and any potential compromise of kidney function, especially when using drugs known to be nephrotoxic.

Table 1. Common drug protocols used by the authors for sedation and anesthesia in camelids (doses are in mg/kg bodyweight, unless otherwise stated)

Drug	Alpacas and llamas	Camels	Remark
Sedation			
Acepromazine	0.15 IM/SQ	0.03 – 0.1 IM 0.01 - 0.02 IV	Urolithiasis
Butorphanol	0.05 - 0.2 IM	0.03 - 0.05 IV or IM	Standing castration
Detomidine	0.04 - 0.06 IM	0.02 - 0.05 IM	Restraint
Diazepam	0.5 - 0.2 IM	0.2 - 0.3 IM	Light to moderate sedation
Xylazine	0.1 - 0.5 IV 0.2 - 0.6 IM	0.1 - 0.25 IV 0.3 - 0.4 IM	Recumbent sedation at high doses
Anesthesia (Recumbency)			
Diazepam + Ketamine	D: 0.2 - 03 IM + K: 5 - 8 IM	D: 0.2 - 0.3 + K: 5 - 8 IM D: 0.1 - 0.2 + K: 3 -5 IV	
Xylazine + Ketamine	X: 0.22 - 0.44 IV + K: 2.2 - 2.5 IV X: 0.22 - 0.44 IM + K: 10 -15 IM 10 minutes later	X: 0.35 + K: 5 - 8 IM X: 0.25 + K: 3 - 5 IV	Anesthesia 30 - 60 minutes
Butorphanol + Ketamine + Xylazine	Alpacas: B: 0.046 + K: 4.6 + X: 0.46 IM Llamas: B: 0.037 + K: 3.7 + X: 0.37 IM	B: 0.3 + K: 3-4 + X: 0.2-0.3 IM	Anesthesia 30 - 40 minutes
Triple drip: Xylazine (1 mg/ml), Ketamine (1 - 2 mg/ml) in 5% guaifenesin	Induction: 0.6 - 1.1 ml/kg Maintenance: 2.2 mg/kg/hour	Induction: 1.1 ml/kg Maintenance: 2 ml/kg/hour	Maintenance CRI to effect
Propofol for induction	2 - 3.5 IV		Can be used for maintenance, but expensive

Urogenital surgeries in the female camelid

Cesarean section (hysterotomy)

Cesarean section in llamas and alpacas may be performed using a left flank or ventral midline approach.[1-3] The flank approach is the best choice under field conditions and for severely compromised patients. In camels, although a left ventrolateral approach has been described,[4] the authors recommend only using a higher left flank approach because of risks of herniation using a ventrolateral approach.[2,5]

For a flank approach, most females tolerate the surgery using local anesthesia with lidocaine administered in a line or inverted "L" block anesthesia (lidocaine diluted to 1% with isotonic bicarbonate or saline, with the total dose not to exceed 4.4 mg/kg) following sedation, caudal epidural and physical restraint in the sitting sternal ("cush") position. The surgical procedure has been described by the authors and is similar to that performed in ruminants, except that the skin incision is oblique, extending from the angle formed by tuber coxae to the base (ventral aspect) of the last rib.[1-3] The incision line should be parallel to the direction of the quadriceps when the animal is sitting in the sternal position (Figure 1).

The subcutaneous muscle and fascia and the external oblique muscle are incised, whereas the internal oblique and transverse abdominal muscle may be gridded along the muscle fibers. The gravid uterine horn (always the left) is grasped around a fetal limb and gently exteriorized from the abdominal incision (Figure 2). A uterine incision is made over the limb at the greater curvature and the fetus is exteriorized (Figure 3). If the placenta is still attached, it should be left in place but peeled away from the uterus 2 - 4 cm along the entire uterine incision to avoid incorporating it into the uterine closure, resulting in subsequent dehiscence. Because of the type of placentation (epitheliochorial and microcotyledonary), mural bleeding is common and hemostasis is provided by over-sewing ("whipstitching") the margins of

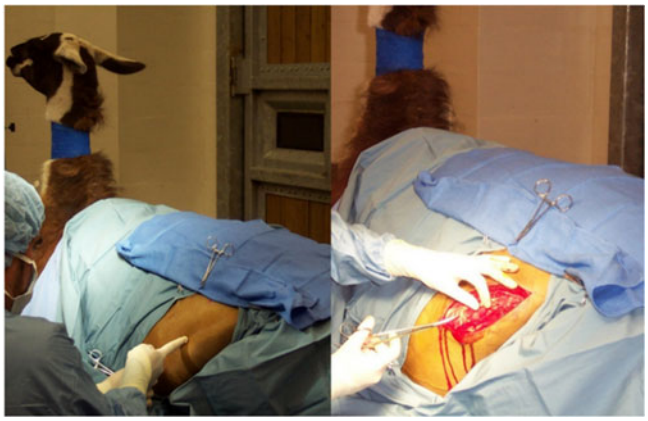

Figure 1. Flank approach for cesarean section in camelids with the patient restrained in sternal position. Note the oblique direction of the incision

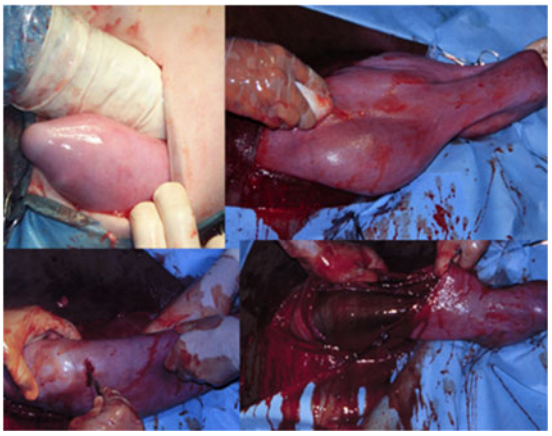

Figure 2. Flank approach for cesarean section in camelids. Exteriorization and incision of the uterus.

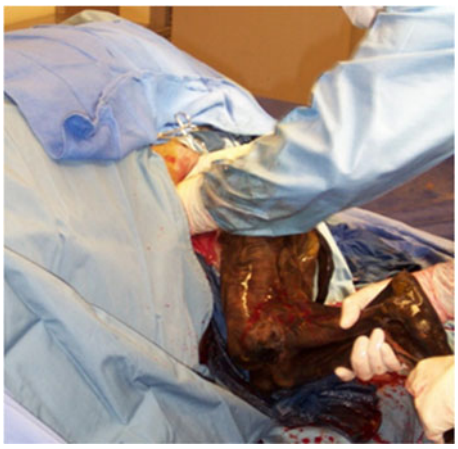

Figure 3. Flank approach for cesarean section in camelids. Uterine incision and delivery of the fetus.

Figure 4. Flank approach for cesarean section in camelids. Uterine suture using an inverting Utrecht pattern.

Figure 5. Flank approach for cesarean section in a llama. Skin suture

Figure 6. Midline approach for cesarean section in an alpaca with a 360° uterine torsion

the uterine incision in a continuous interlocking pattern using absorbable suture material. The uterine wall is closed in a Cushing, Utrecht, or Lambert pattern using absorbable suture material (Figure 4). If the uterus appears healthy, a single layer closure is sufficient; however, if there is compromise, a double layer closure is recommended. The uterine wall and abdominal cavity may be lavaged with a warm sterile saline solution containing antibiotics (penicillin G potassium 22,000 units/kg, ampicillin sodium 20 mg/kg, or ceftiofur sodium 1 mg/kg), and heparin (20 - 40 units/kg). Carboxymethyl cellulose (14 ml/kg, intraperitoneally) may be used to prevent postoperative adhesions. The abdominal cavity and skin are closed in the same manner as for ruminant cesarean section (Figure 5).

The midline celiotomy approach is performed in alpacas and llamas in dorsal recumbency under general anesthesia; this is the preferred approach if the uterus is compromised or has undergone torsion (Figure 6). A midline celiotomy incision (25 - 30 cm in alpaca and 35 - 40 cm in llamas) is made through the skin, subcutaneous fat, cutaneous trunci muscle and linea alba from ~ 4 cm cranial to the border of the mammary gland extending towards the umbilical scar. The uterus is identified by direct palpation and exteriorized. An incision is made through the uterine wall along the greater curvature. The fetus is removed and the umbilicus clamped and transected. Uterine closure is as described above. This technique can be used to resolve preterm uterine torsion without delivery of the fetus if it is still alive.[6] If the fetus is dead or at term (dystocia due to uterine torsion), the fetus is delivered, then the torsion corrected. The linea alba is closed using absorbable suture material (No. 2 polyglycolic acid or No. 1 polydioxanone or polyglactin 910) in an appositional interrupted (horizontal mattress, cruciate) or continuous suture pattern. Closure of the skin may be achieved with staples, horizontal mattress suture pattern, Ford interlocking suture pattern or preferably where possible, a subcuticular suture pattern (No. 2-0 polyglactin 910 or polyglecaprone).

Postoperative care includes pain management for 3 - 5 days. Antimicrobial prophylaxis should be continued for 5 - 7 days, depending on the condition of the uterus and fetus at the time of surgery. Fluid therapy may be indicated in some cases. The dam should be monitored for clinical signs of postpartum metritis and toxemia. The placenta is generally expelled within a few hours of surgery if the cervix is open or 2 - 4 days if it was closed at the time of surgery. Oxytocin may be administered (20 IU IM in camels and 5 - 10 IU IM in south American camelids) every 4 hours during the first 24 hours postsurgery, if the cervix is open. Administration of cloprostenol IM (125 - 250 µg in alpacas, 250 µg in llamas, and 500 - 750 µg in camels) is recommended if the surgery was performed to remove a dead fetus due to uterine torsion.

Complications of cesarean section in camelids include retained fetal membranes, incisional infection, herniation, peritonitis, intestinal adhesions, and infertility (Table 2). However, these complications are minimal when the surgery is performed early in dystocia.[7-9] The most common complications seen in camel cesarean sections, performed by the authors in the field, were incisional infections (myasis) and herniation.

The rebreeding success rate is excellent (> 70%) following cesarean section, and most females will rebreed successfully 3 - 4 months postsurgery.[6-9] The earliest successful rebreeding post cesarean section seen by the author is 45 days. The authors generally recommend at least 45 - 60 days of sexual rest, with a thorough prebreeding examination prior to any breeding following a cesarean section.

Ovariectomy/ovariohysterectomy

Ovariectomy is usually performed to prevent sexual activity and eliminate pregnancy risk or to remove a diseased organ (e.g. ovarian masses, ovariobursal adhesions).[10] Ovariohysterectomy is rarely performed in camelids, but may be considered in cases of uterine or cervical masses and mucometra.[11] Ovariectomy or ovariohysterectomy should ideally be performed during the luteal phase of the cycle, so that the uterus is relaxed and complications associated with hemorrhage are reduced. Alternately, females should be given progesterone (progesterone in oil IM or intravaginal CIDR) for 7 - 10 days prior to surgery.

Table 2. Indication and outcome of cesarean sections in camelids

Reference	Campbell et al: 2013*	Miller et al: 2013*	Tibary et al: 2015**
No. females	24	31	76
Primarous (%)	45.8	-	-
Multiparous (%)	54.2	-	76
Uterine torsion (%)	61	38	0.5
Fetal maldisposition (%)	21.7		
Failure of cervical dilation (%)	8.7	17.5	81.65
Other (%)	8.6	22	
Dam survival (%)	91.2	86	92.1
Neonate survival (%)	46	59	81.6
Complications			
Retained fetal membranes (%)	8.3	88	15.7
Metritis (%)	-	-	2.9
Other complications (%)	-	-	20
Postsurgical fertility (%)	70	90.5	70.8

*Llamas and alpacas, **dromedary camel recipients in an embryo transfer center

In alpacas and llamas, ovariectomy may be performed using a parainguinal, ventral midline or flank approach. Laparoscopic and laparoscopic-assisted techniques are described in subsequent sections of the present paper. The choice of a particular technique depends on the age of the animal, the side of the ovary concerned (unilateral or bilateral), and the status of the ovary (normal versus abnormal). The flank approach is considered the best for camels.[2,10] The technique is similar to the approach described for cesarean section, except that the incision is vertical and gridding is possible (Figure 7).

For a ventral midline approach, the anesthetized animal is placed in dorsal recumbency. A small (6 - 8 cm) incision is made on the ventral midline just cranial to the udder and continued into the abdominal cavity as described for cesarean section. The surgeon introduces 2 fingers into the abdominal cavity. The urinary bladder is identified, and the uterus is recognized in its dorsal aspect by following 1 of the horns to the uterine bifurcation. Vaginal manipulation with a sterile tube speculum or blunt ended rod by an assistant may help the surgeon locate the uterus. One uterine horn is grasped between the fingers and pulled towards the surgical incision. Both horns are exteriorized by gentle traction, followed by exteriorization of the ovaries.

For ovariectomy, the vascular pedicle of the ovary is isolated by passing forceps through the mesovarium, making sure to incorporate the ovarian artery and vein. A size 0 absorbable suture material is used to transfix the ovarian pedicle before transection. Large ovarian masses (e.g. granulosa theca cell tumor, teratoma) may require placement of overlapping transfixing sutures on the pedicle to prevent hemorrhage (Figure 7).

For hysterectomy or ovariohysterectomy, the mesometrium and broad ligament of each uterine horn are transected after ligation of blood vessels. Transfixation and circumferential ligatures, using absorbable suture, are placed proximal to the cervix. The surgeon should make sure to include the large uterine vessels located on each side. The uterus is transected at the level of the body between 2 hemostatic forceps. If the remaining portion of the uterine body is large, it should be closed with an inverting suture pattern before replacing it in the abdomen. Removal of 1 horn or portion of a uterine horn (a partial hysterectomy) is sometimes used in research settings or for treatment of pathology confined to one side of the abdomen. The technique is similar to a total hysterectomy, although a flank approach would be more possible. The vasculature supplying the ovary and ipsilateral horn is ligated and transected. Pregnancy is only possible if the left uterine horn with the ipsilateral ovary are normal and maintained. However, embryos may still be collected from females with right uterine horn and normal ipsilateral ovary.

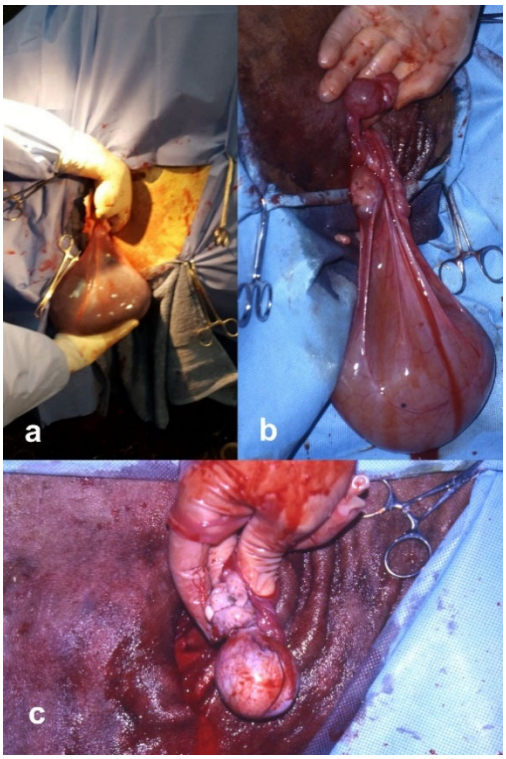

Figure 7. Paralumbar flank approach to ovariectomy in camels; a - b) removal of an ovary encapsulated with ovariobursal adhesions, c) removal of an ovarian teratoma

Postoperative care should include antimicrobial therapy and pain management. There are very limited risks of complication with ovariectomy. However, ovariohysterectomy may have a higher risk, due to intraoperative hemorrhage, adhesion formation and stump complications.

Laparoscopic techniques

Laparoscopy is widely used in reproductive research and for exploration of the abdomen and urogenital system abnormalities.[12-14] The technique requires the use of a rigid laparoscope with a diameter of 6 - 10 mm and various lens angles, depending on the indication for the procedure. For most reproductive techniques in alpacas, we use a 6 mm diameter laparoscope with a 0 or 30° angle. This allows for minimal incisional size for portal placements. Standing laparoscopy may be used in llamas and camels using a 10 mm diameter laparoscope. For alpacas, laparoscopy is usually performed on the sedated or anesthetized animal in dorsal recumbency on a surgical table that can be tilted into Trendelenburg position. Animals should be fasted for at least 24 hours prior to the procedure to reduce forestomach compartment (C-1) fill and reduce risk of regurgitation.

Standing laparoscopy

Standing laparoscopy is performed mainly in llamas and camels for in situ observation of the genital organs or ovariectomy (Figure 8). The female is restrained in stocks and sedated with butorphanol tartrate. The left paralumbar fossa is prepared for aseptic surgery and 2% lidocaine is infused into the subcutaneous and muscular tissues in an inverted "L" pattern to desensitize the region (Figure 8).[15,16]

A small (10 - 15 mm) skin incision is made in the craniodorsal portion of the paralumbar fossa caudal to the12th rib (4.5 cm in llamas, 8 - 12 cm in camels) and ventral to the transverse processes of the lumbar vertebrae (8 cm in llamas and 12 - 15 cm in camels). This provides a portal for a 30° laparoscope, which is placed after penetrating the abdominal cavity through the abdominal musculature and peritoneum using an appropriate trocar. The abdomen is insufflated with CO_2 to a pressure of 10 mm Hg.

Figure 8. Standing laparoscopy in llamas and camels. Sites for laparoscope (1) and instrument portals (2 & 3)

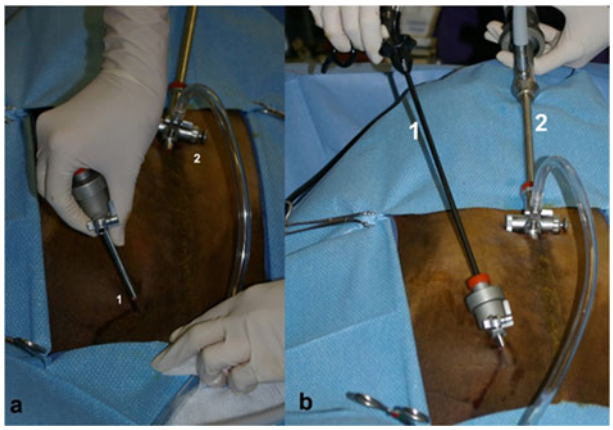

Figure 9. Ventral midline laparoscopy technique. Placement of the endoscope portals (1) and manipulation forceps portal (2).

Figure 10. Examples of abnormalities diagnosed by laparoscopic examination of the reproductive tract in alpacas. a) ovarian hypoplasia/dysgenesis, b) ovarian neoplasia, c) uterus unicornis, d) ovarian neoplasia, e) hydrosalpinx, f) adhesions

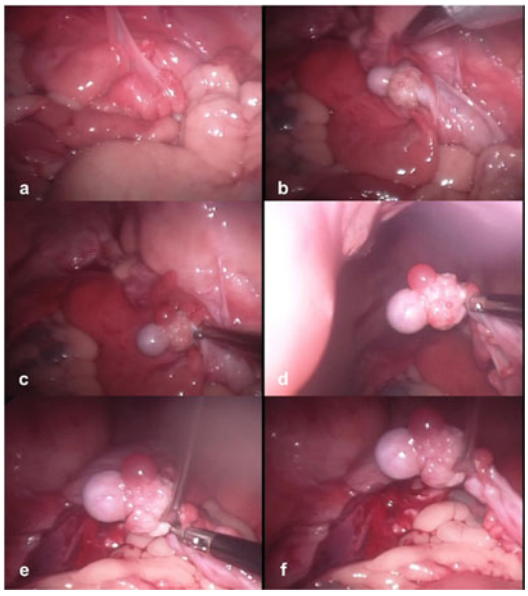

Figure 11. Laparoscopic-assisted ovariectomy in an alpaca. Ovary is dislodged from its bursa (a - b) then held with forceps from the pedicle and elevated to body wall (c - d). An allis forceps is introduced through a midline incision to hold the ovary and exteriorize it (e - f).

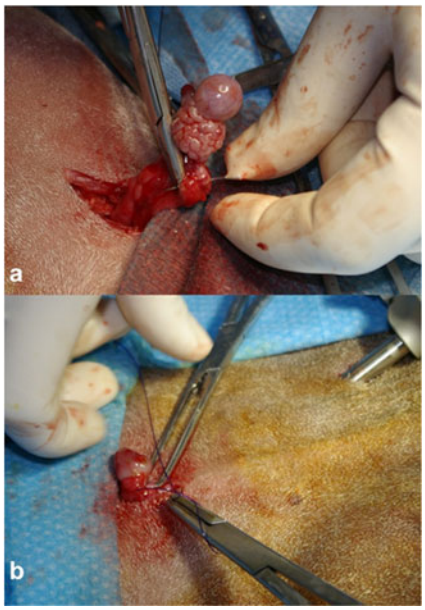

Figure 12. Laparoscopic-assisted ovariectomy in an alpaca. Pedicle of exteriorized ovary (a) is a transfixing ligature placed before excision (b).

Each ovary is identified by following the respective uterine horn from the uterine bifurcation to the tip of the uterine horn. This manipulation may be difficult if the urinary bladder is distended. Catheterization of the bladder with a Foley catheter prior to the procedure is helpful. Once the genital tract has been located and inspected, a second incision is made in the skin of the caudodorsal portion of the left paralumbar fossa caudal to the 12th rib (10 cm in llamas and 15 - 18 cm in camels) and ventral to the transverse process of the lumbar vertebrae (10 cm in llamas and 15 - 20 cm in camels). This incision will provide the portal for a manipulation instrument (grasping forceps) to be inserted through a cannula fitted with a sharp trocar. A small incision is then made in the skin of the caudoventral region of the left paralumbar fossa caudal to the 12th rib and ventral to the transverse processes of the lumbar vertebra to provide a portal for the introduction of a ligature guide holding a loop of size 0 polydioxanone. The ovary is grasped with the forceps through the suture loop. The ligature is pushed to the level of the ovarian pedicle and tightened around it. The ligature guide is removed, and scissors are introduced to cut the end of the ligature and transect the ovarian pedicle at the base of the ovary. The ovary is removed from the abdomen with the grasping forceps. All instruments are removed. It is important to ensure that excess gas is expelled prior to removal of the cannulas to avoid postoperative discomfort. To close portal incisions, use a single cruciate suture with 3-0 polyglyconate for the external oblique muscle and a single cruciate suture of 3-0 monofilament nylon for the skin.

Ventral abdominal approach

The anesthetized patient is placed in dorsal recumbency. The ventral abdomen is clipped and surgically prepared from the cranial edge of the mammary gland to the xiphoid. The laparoscope portal is made over the umbilical scar or a few centimeters caudal to it (Figure 9). A 10 - 15 mm skin incision (size depending on the diameter of the laparoscope) is made on the midline at the level of the umbilicus or 3 - 5 cm caudal to it, depending on the technique and length of the endoscope.[1, 17-20] A controlled 2 - 3 mm stab incision is made on the linea alba and a teat canula or a verses needle is used to penetrate through the linea alba and peritoneum into the abdomen. Adequate penetration of the abdomen can be verified by injecting sterile saline through the canula. The abdominal cavity is insufflated with CO_2 to a partial pressure of 10 -15 mm of Hg. A cannula fitted with a pyramidal trocar is inserted at this level through the linea alba and peritoneum into the abdomen. The trocar is removed and replaced with a laparoscope. The pelvic inlet is identified by tilting the surgical table to 40 degrees to elevate the hind legs and displace the abdominal viscera cranially (Trendelenburg position).

For in situ examination of the reproductive tract, instruments portals are made lateral (left and right) to the midline midway between the scope portal and the caudal aspect of the fold of the flank. The uterus is located under the urinary bladder and each uterine horn is followed to its tip and elevated to allow visualization of the ipsilateral ovary. Atraumatic grasping forceps are used to manipulate the uterus and bladder for location and visualization of the ovaries (Figure 10).

For ovariectomy, the ovary is dislodged from the ovarian bursa by gentle manipulation until the mesovarium and proper ligament of the ovary are isolated (Figure 11). Hemostasis may be provided by two Hulka clips across the mesovarium or proper ovarian ligament, or a suture loop may be placed around these structures. The proper ligament is incised with scissors proximal to the clips or suture.[17,18] Alternately, the ovary is grasped at the level of its pedicle after exteriorization from its bursa and elevated to the abdominal wall (Figure 11). An incision is made through the skin and linea alba as far caudal as possible, to avoid excessive tension on the ovary. A pair of Allis forceps is introduced through the incision into the abdomen and the ovary is grasped exteriorized (Figure 12). A transfixing suture is placed on the ovarian pedicle, using PDS-0, prior to excision of the ovary with scissors (Figure 12). The procedure is repeated on the other ovary.[19] Closure of the external abdominal musculature (portal locations) and the linea alba is achieved using 2 polyglycolic acid in a cruciate and simple continuous pattern, respectively. The skin is closed with 2-0 polypropylene using a simple cruciate suture.

For laparoscopic ovariohysterectomy, the female is prepared in the same manner as for ventral midline laparoscopic ovariectomy. However, this technique requires more expertise in the handling of surgical instruments through laparoscopy. The procedure starts with ligation of the ovarian vessels. The

mesovarium is exposed and incised, after hemostasis has been established using a series of clips (Ligaclip®) inserted into the left portal. The broad ligament is transected close to the uterine horn caudal to the uterine body, avoiding the uterine artery. The same procedure is repeated on the other side. Once both uterine horns are freed, a ligature loop is introduced and passed around the uterine horns and ovaries all the way to the level of the uterine body, where it is tightened. A second ligature loop is placed in the same manner around the uterine body to provide adequate hemostasis. The uterus is transected, after placing a third loop along the portion of the uterus to be removed (to prevent loss of uterine content into the abdomen). The uterus and ovaries are removed from the abdominal cavity from 1 of the instrument portals after increasing its size.[20]

Laparoscopic assisted ovum pickup

In preliminary trials by the authors, laparoscopic ovum pickup can be an alternative to laparotomy for alpacas.[21] The technique is similar to that describe above for laparoscopic-assisted ovariectomy. Once the ovary is exteriorized from its bursa, an 18 gauge, 6 cm needle attached to an aspiration pump is introduced through the abdominal wall and follicles are aspirated. The recovery rate obtained (56.1%) was lower than the laparotomy technique.

Rectovaginal tear

Perineal lacerations are classified using the same system described for mares. The majority of cases observed by authors are third-degree and occasionally second-degree perineal lacerations. The occurrence of third-degree lacerations is common after severe dystocia, due to the small perineal body in these species (Figure 13).

Superficial lacerations can be repaired quickly under local anesthesia using a Caslick's procedure if the tear has already epithelialized. Second-degree lacerations require reconstruction of the perineal body, generally after sedation and epidural anesthesia. Repair of the third-degree perineal laceration and rectovaginal fistulas should be delayed until the tissue has granulated and epithelialized. Although some practitioners may perform this operation as early as 2 weeks after injury, it is the authors' preference to wait 4 - 8 weeks postpartum. Repair of third-degree laceration can be performed standing in camels. In llamas and alpacas, we prefer to have the patient heavily sedated or under general anesthesia in a sternal position (Figure 14). In sedated animals, epidural anesthesia is helpful, as rectal and vulvar tissues need to be retracted using suture or retractors. Repair techniques are similar to those described for the mare and consist of dissection of the rectal and vaginal walls, with the goal of creating a new separate rectovaginal shelf. The rectal and vaginal layers are closed with monofilament absorbable suture (2-0 or 3-0 PDS in llamas and alpacas, 0 or 1 PDS in camels). The perineal body is sutured separately, followed by skin suture.[22]

Rectovaginal fistula

In the authors' experience, rectovaginal fistulas in camelids involve primarily the vestibular area (rectovestibular fistulas). They are better corrected by converting them to a complete rectovaginal tear prior to correction.

Chronic vaginal prolapse

Vaginal prolapse is relatively common in camelids, and particularly in heavy breeds of camels, in the last 2 months of pregnancy.[23] Predisposing factors include age (older females), parity, and body condition (obese or very thin females).[3] In late-term animals, vaginal prolapse may be the first sign of a uterine torsion.

Prolapse of the entire vagina and exteriorization of the cervix is rare. Prolonged periods of prolapse lead to increased inflammation, resulting in severe necrosis of the vaginal mucosa. In some cases, ascending infectious placentitis is possible. In camels, myiasis of the prolapsed tissue is not uncommon (Figure 15). Chronic cases are at risk of abortion and/or rectal prolapse due to persistent tenesmus. Rectal and vaginal prolapse may be the only sign of uterine torsion, dystocia or abortion.

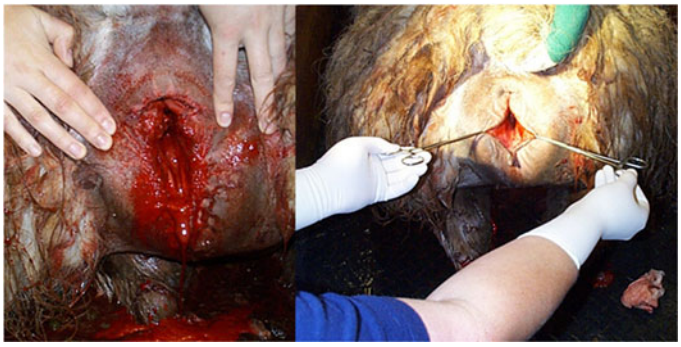

Figure 13. Third-degree perineal laceration following dystocia and fetotomy in a llama

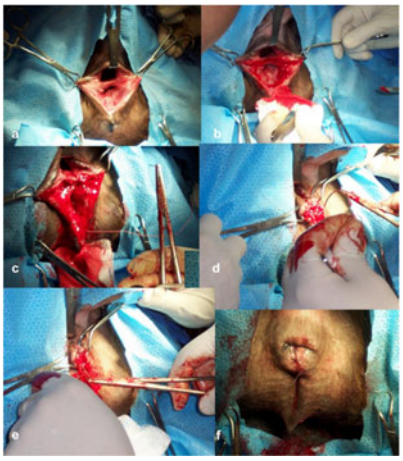

Figure 14. Third-degree rectovaginal laceration repair in an alpaca. a - b) incision and dissection to separate the rectum from vaginal vestibule, c - d) Apposition of the flaps of tissue with sutures, ensuring that the rectal mucosa is apposed and the vestibular mucosa is everted into the vestibule. e - f) the perineal body is sutured using a simple interrupted pattern

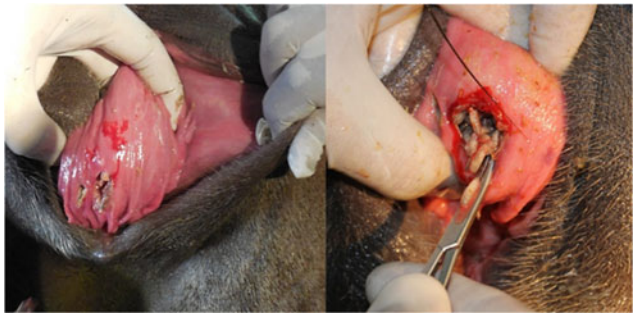

Figure 15: Myasis complication of a chronic vaginal prolapse in a dromedary camel

Figure 16. Cercalge suture technique in an alpaca with recurrent vaginal prolapse due to rupture of the vestibule-vaginal sphincter. Left to right, the vaginal tissue is cleaned and replaced, a purse string suture is placed around the vestibular suture and a Caslick suture is placed to reduce the side of the vulva.

Figure 17. Uterine prolapse in a dromedary camel (left) and an alpaca (right)

Figure 18. Episioplasty to repair a narrow vulva opening (incomplete atresia vulvi)

The prognosis for the life of the fetus and dam is relatively good if the condition is treated early. Prolapsed vaginal tissue is cleaned and replaced after sedation and epidural analgesia. In camels, the vaginal tissue is maintained in place by a Bühner suture around the vulva.[23] In alpacas and llamas, the vulva can be sutured with light umbilical tape, using a long postmortem needle in purse string or a shoelace suture pattern.[24] Sheep vaginal prolapse retainers have been used successfully to manage vaginal prolapse in alpacas.[25]

Recurrent vaginal prolapse in postpartum alpacas and camels has been observed by the authors. In these cases, the vestibulovaginal sphincter may be compromised and the bladder may be entrapped in the prolapsed tissue. After replacement, the vestibular sphincter is held in place with an encircling suture using heavy resorbable suture material (Figure 16). Although the general recommendation is not to rebreed females with vaginal prolapse during pregnancy, there is no evidence for a hereditary nature of vaginal prolapse.

Uterine prolapse

Partial or total uterine prolapse can occur secondary to dystocia, abortion, manual removal of a retained placenta or excessive use of oxytocin (high dosage and frequency). Uterine prolapse is more common in camels than in llamas and alpacas, and is often associated with hypocalcemia, selenium deficiency and retained fetal membranes, particularly in dairy camels (Figure 17).[2,26-28] Uterine prolapse generally occurs immediately (the first 60 minutes) after parturition or abortion.

Techniques for replacement are similar to those reported in cattle under sedation and epidural analgesia. The placenta is often easily peeled off and should be removed, if possible, prior to replacement of the uterus. The female is positioned in sternal recumbency, with the hind quarters slightly elevated. The uterus should be inspected for any lacerations or hemorrhage. The area of major risk for hemorrhage is located near the cervix where the uterine artery may be exposed. The uterus is cleaned with warm dilute povidone iodine solution before replacement. The vulva is sutured with a Bühner suture in camels or a shoelace pattern in alpacas and llamas. Uterine prolapse tend to recur if the uterine horns are not fully extended. Hysterectomy may be considered if the uterus has sustained severe damage; however the prognosis for survival in these cases is poor.[27,29]

Vulvoplasty/episioplasty

Episioplasty is often considered in females with atresia vulvi or a recessed vulva (Figure 18). The surgery is straight forward and aims at extending the commissures of the vulva. However, owners should be warned about the possible hereditary nature of atresia vulvi and breeding these females should be discouraged.[30-32]

Vaginal adhesions

Vaginal adhesions are common complications of overt obstetrical manipulations or fetotomy in camelids.[3] Laser surgery may be considered in some cases;[33] however adhesions often reform and in some cases, the surgery cannot be performed without risk of affecting the urethra (Figure 19).

Figure 19. Vaginal adhesions in alpaca following fetotomy

Urogenital surgeries in the male camelid

Castration

Castration at an early age delays closure of the long-bone physes, resulting in tall, post-legged geldings and a predisposition to early onset of degenerative osteoarthritis or patellar luxation. The authors' recommended age for elective castration is 15 months for alpacas, 18 months for llamas and 2 years for camels. Precastration considerations include examination of the scrotum for testicular descent, lesions or adhesions. Presurgical administration of tetanus toxoid vaccination and antimicrobial therapy is recommended (Procaine penicillin G is generally given at 22,000 U/kg SC or IM before castration and daily for 3 days, or long acting ceftiofur 6.6 mg/kg SC once). Although the prescrotal technique has been described most practitioners use the scrotal approach.

The scrotal technique can be performed on the standing animal in llamas and camels, although lateral recumbency is recommend for alpacas.[1,34] Standing castration is performed after sedation with butorphanol alone or combined with xylazine, followed by local scrotal and testicular infiltration of lidocaine. If castration is to be performed in lateral recumbency, a combination of xylazine, ketamine, and butorphanol is indicated. The scrotum is prepared for aseptic surgery and an incision is made along the most ventral aspect of the scrotum, with the scrotal skin taught by holding the testis firmly into the scrotum. The testis is exteriorized and held with a towel clamp while the testicular cord is gently stripped from fat and connective tissue, using a piece of gauze (Figure 20). The testis is removed using an emasculator (adult llamas) or after transfixation ligation of the spermatic cord with No. 0 (llamas, camels) or No. 2-0 (young llamas and alpacas) absorbable suture material. Unilateral castration is indicated in breeding males with a unilateral testicular disorder such as orchitis, trauma, or neoplasia (Figure 21).[29] The procedure is similar to conventional castration, except that a primary closure is recommended to promote fast healing and reduce the effects on the remaining testis. The vaginal tunic is closed with a simple interrupted pattern using absorbable suture material. Excess scrotal skin is removed and the subcutaneous tissue is apposed and closed with a simple continuous pattern. The skin is closed with a simple interrupted pattern using nonabsorbable suture material.

Postoperative care for castration includes antimicrobial therapy and confinement in a small pen for 24 hours. Topical antiseptic and fly spray are indicated under farm conditions. The animal should be observed for excessive bleeding or swelling, exudative discharge due to infection, and difficulty urinating. However, postcastration complications are rare (Table 3), and excessive bleeding can be managed by scrotal packing with gauze. Hemostatic agents are very helpful in controlling the hemorrhage in some cases. Under field conditions, the most common complication in camels is local wound infection and scirrhous cord development (Figure 22). It is important to inform the client that some males may continue displaying copulatory activity even after castration.

Cryptorchidectomy

Cryptorchidism is more frequent in alpaca and llamas than in camels.[35,36] In 1 study in alpacas, there was 3% unilateral cryptorchidism in 792 animals. The left testis seems to be slightly more affected than the right testis (58.3 versus 41.7%).[37]

Table 3. Complications following castration to remove normal descended testes in camelids

Complications	Llamas and alpacas*		Camels*	
	No.	%	No.	%
No complications	168	92.3	47	73.4
Anesthesia complication	1	0.5	-	-
Slight hemorrhage	4	2.2	-	-
Severe hemorrhage	1	0.5	-	-
Severe scrotal edema/preputial edema	8	4.4	15	23.4
Scirrhous cord	-	-	2	3.1
Total	182		64	

*All of these castrations were performed by veterinary student

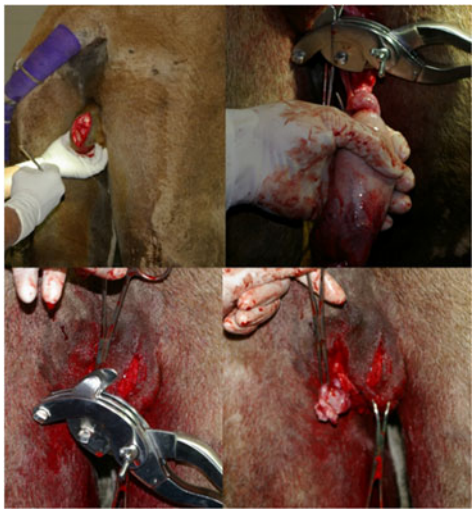

Figure 20. Standing castration in dromedary camels

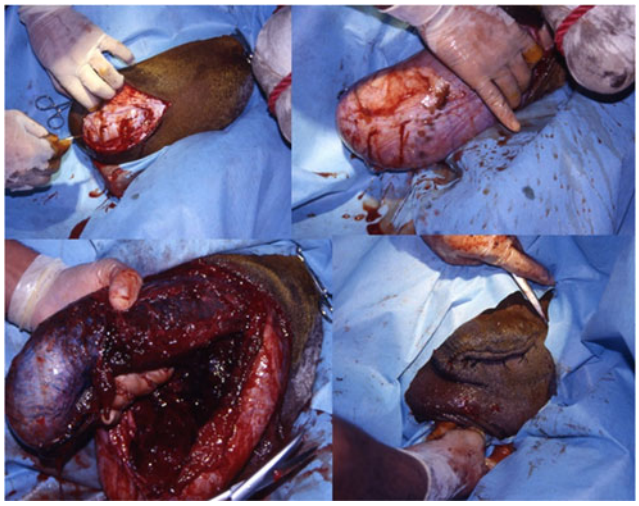

Figure 21. Unilateral castration with primary closure in a dromedary with a severe testicular hemorrhage and hematoma due to a biting injury

Figure 22. Scirrhous cord in a 12 year old male dromedary following castration

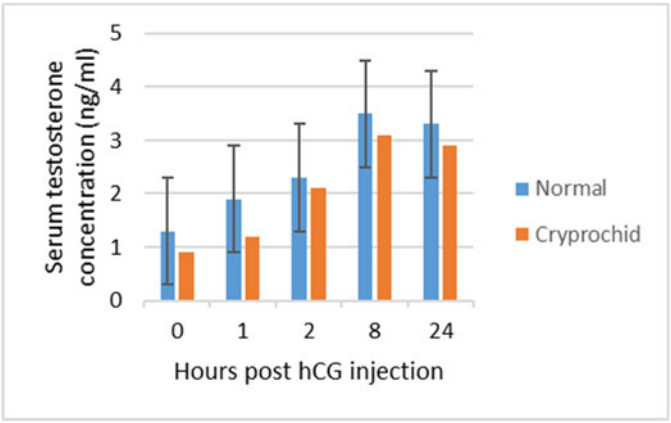

Figure 23. Serum testosterone concentrations in intact male alpacas (n = 8) and cryptorchid unilaterally castrated alpacas (n = 3) before and after hCG challenge

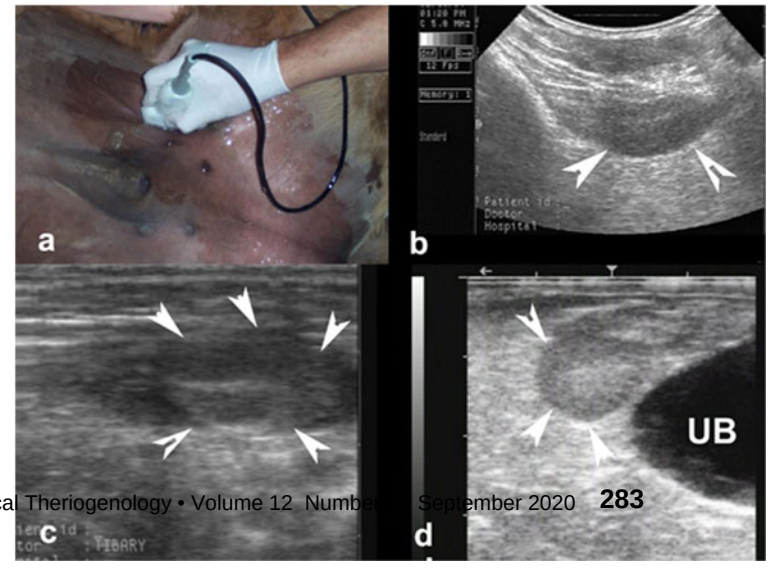

Figure 24. Ultrasonogram of a retained testis in a Bactrian camel (percutaneous inguinal, a - b) and alpaca (transrectal) (c - d, UB: urinary bladder

Surgical approaches for cryptorchidectomy include flank, inguinal and parainguinal laparotomy[40] or laparoscopic assisted techniques.[36] For camels, the parainguinal approach is favored by the authors in camels.[35] The retained testis is often in proximity to the vaginal ring and may be retrieved using a spay hook. In some cases, direct exploration of the abdominal cavity is necessary.

For the parainguinal approach, the inguinal canal is located by palpation and a 1 cm skin incision is made medial to the caudal border of the external inguinal ring and extended cranially 3 - 4 cm. The incision is continued carefully through all tissue layers into the peritoneum. The abdominal cavity is entered using 2 fingers and the retained testis is identified by palpation of the area around the incision. The cryptorchid testis usually lies just lateral to the vaginal ring. Once identified, the testis is grasped and brought up to the incision site (Figure 25). The spermatic cord is ligated with 2-0 polyglactin 910 and resected. The internal abdominal oblique muscle is closed with 0 polyglactin 910 in a continuous pattern. The fascia of the external abdominal oblique muscle is closed with 1 polyglactin 910 in a simple interrupted or simple continuous pattern. To close the skin, a subcuticular closure in a simple continuous pattern is sufficient. Postoperative care should include nonsteroidal antiinflammatories and antimicrobials for 3 and 5 days, respectively.

Laparoscopy-assisted cryptorchidectomy offers the advantages of speed and reduced manipulation of the abdominal contents. The animal is placed in dorsal recumbency under general anesthesia and the ventral abdomen is prepared for surgery. The laparoscope portal may be placed over the umbilical scar. The intraabdominal testis is located and the second portal is placed laterally to the prepuce and used to introduce grasping forceps. The testis is grasped and elevated toward the inguinal area where a small parainguinal incision is made to exteriorize the testis (Figure 26).[36]

A complete laparoscopic technique for cryptorchidectomy has been described and requires the use of 3 ports. The laparoscope portal is placed as described above and 2 instrument portals are placed on each side, ~ 5 cm from the prepuce. One portal is used to grasp the testis while the other is used to introduce laparoscopic, bipolar, electrocautery forceps. The spermatic cord is cauterized and transected and the testis is removed through the grasping instrument portal (Figure 27). The portal may need to be enlarged at this point. Portal sites are closed with a simple interrupted suture pattern. The skin is closed in cruciate pattern.[36]

Vasectomy

Vasectomy is performed primarily for preparation of teaser males and for experimental studies where natural induction of ovulation (presence of ß subunit of nerve growth factor in seminal plasma) without fertilization is desired. In alpacas and llamas, vasectomy may be performed via laparoscopy or a prescrotal technique under general anesthesia (Figure 28, 29).[36,41] The inguinal region is clipped and surgically prepared. The spermatic cord is palpated lateral to the penis, caudal to the inguinal ring. A 2 cm skin incision is made over the spermatic cord and the vaginal tunic opened with a stab incision. The ductus deferens is isolated with hemostats. A 2 cm segment is isolated by blunt dissection and 2 ligatures of 2-0 polydioxanone are placed on each side of the segment prior to incision. The tunic is left open and the skin closed using 2-0 polydioxanone in a subcuticular pattern.[42,43] Epididymectomy is an alternative to vasectomy, but is not favored by the authors (Figure 30).[29] Vasectomized males are sterile by 3 weeks after surgery.

Preputial prolapse, paraphimosis

Preputial lacerations are usually a consequence of masturbation behavior (breeding the ground or objects) or complications from foreign bodies within the prepuce. Hair rings around the penis are common in llamas and Suri alpacas. Presenting complaints may be similar to those for urolithiasis. In some cases, the only sign is preputial bloody or purulent discharge. Complications resulting in local adhesions and prevention of urination are possible.[2,44] The penis and prepuce are evaluated under heavy sedation or general anesthesia. Early management of preputial and penile injuries should center on providing adequate protection of the traumatized tissue (and prevention of infection and complication with urine scalding ointment containing lanoline, castor oil and antibiotics).[45]

Figure 25. Parainguinal approach to cryptorchidectomy in a Bactrian camel

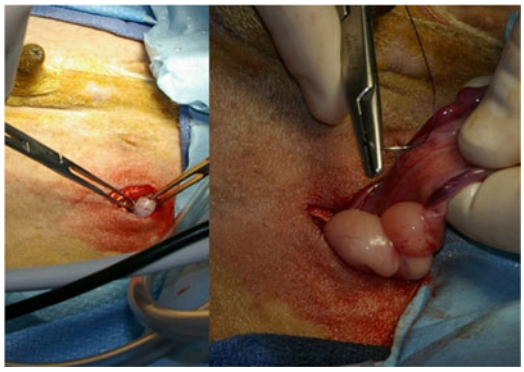

Figure 26. Laparoscopic-assisted cryptorchidectomy in a male alpaca

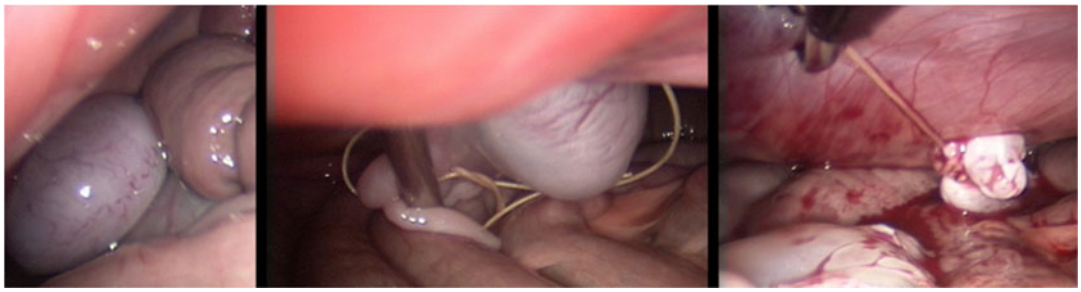

Figure 27. Laparoscopic cryptorchidectomy in a male llama

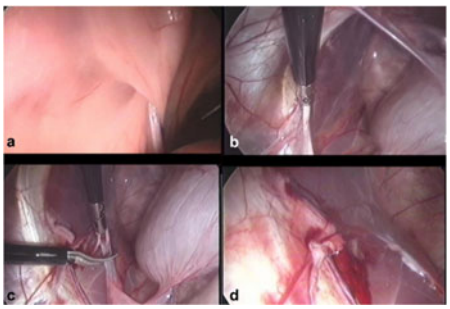

Figure 28. Laparoscopic vasectomy in a male alpaca. a) Identification of the vaginal ring, b - d) transection of the vas deferens

Figure 29. Inguinal vasectomy technique in camelids

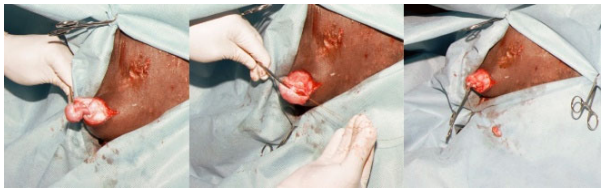

Figure 30. Cauda epididymectomy in camel

Replacement of the healthy prolapsed preputial mucosa and its retention with a purse string suture is helpful in early cases (Figure 31). Daily cleaning of the sheath with saline and application of local antiinflammatory and antimicrobial ointment for 3 - 5 days will reduce the chance of further complications. Sutures may be removed after 7 - 10 days. Excessive preputial prolapse with slight necrosis requires circumferential resection and anastomosis of the prepuce. Long standing lesions have a poor prognosis, particularly if there is overt cellulitis and tissue necrosis (Figure 32). Paraphimosis is a common complication (Figure 33). Tissue necrosis is a common problem with these cases and may include the penis due to pressure ischemia. Surgical debridement and/or phallectomy may be required in these cases. In valuable racing camels, sand masturbation, the leading cause of preputial problems, is prevented by application of preputial rings (Figure 34).

Soft palpate (dulla excision)

The soft palate (dulla) is exteriorized frequently during the rutting season in the dromedary.[46] Impaction of this diverticulum with food or foreign bodies results in entrapment of the tissue under the molars and traumatization during mastication (Figure 35). Severe edema and abscess formation are common complications, resulting in a permanent exteriorization and dysphagia.[47,48] In rare cases, the soft palate is swollen but not exteriorized and blocks respiration, which may lead to asphyxiation.[49] Surgical management (i.e. palatectomy) is the best course of action. Excision of the prolapsed "dulla" is performed under heavy sedation or general anesthesia. The prolapsed tissue is excised after careful ligation of large vessels.[49-52] Postoperative care includes NSAIDs, antimicrobials and tetanus prophylaxis. Animals should be on soft food for 3 to 4 days after surgery.[29,51] Palatectomy is often performed at a young age in racing camels to improve airflow during the breeding season.

Rectal prolapse

Rectal prolapse is common in obese male camels following excessive breeding, but can also be the results of other factors (e.g. diarrhea, excessive tenesmus, neoplasia, urolithiasis).[53,54] It is classified in 3 degrees or types: Type 1 involves the rectal mucosa and submucosa, Type 2 involves the full thickness of the rectum and Type 3 may include intussusception of some small colon (Figure 36).[55] Types 1 and 2 are the most commonly encountered in breeding males and require sexual rest and sometimes surgical intervention. The rectal mucosa is replaced manually and retained with a purse string suture around the anal sphincter using a heavy nonabsorbable suture. The suture is left in place for 5 - 10 days. Mucosal resection and anastomosis are indicated if the mucosa is damaged. Amputation of the rectum is the last resort and carries a poor prognosis.[53,54,56]

Cystotomy

Urolithiasis is relatively common in camelids. The etiology of urinary calculi in these species is not well understood but is suggested to be similar to that in other domestic ruminants.[57,58] Clinical signs include persistent straining, odontoprisis, anorexia and ileus, anorexia, dribbling blood-tinged urine, and signs of abdominal discomfort.[58,59] More severe clinical signs ensue in cases of complete blockage and rupture of the urethra or bladder. Fluid from abdominocentesis or the preputial swelling has increased creatinine concentration.[59] Increased serum urea nitrogen and creatinine concentrations suggest presence of uroperitoneum. Transcutaneous ultrasonography of the ventral abdomen may show subcutaneous free fluid and tissue edema in the case of urethral rupture and large volumes of free fluid in the abdominal cavity in the case of urinary bladder rupture. In the latter case, the urinary bladder may not be possible to image. Transrectal ultrasonography may reveal dilation of the pelvic urethra if the bladder is intact. Prognosis is grave in the presence of hydroureter and hydronephrosis.

Uroliths are often located in the distal penile urethra, ~ 7 - 12 cm from the penile orifice but may occasionally be found immediately proximal to the sigmoid flexure. Muscle relaxation and sedation may be obtained with acepromazine and diazepam (0.1 mg/kg slow IV). The urethral recess (diverticulum) at the ischial arch makes catheterization and retropulsion of uroliths impossible. The penis should be exteriorized and the tip of the glans penis (urethra) examined for presence of calculi (Figure 37).

Figure 31. Preputial mucosa prolapse and replacement in an alpaca

Figure 32. Preputial necrosis in an alpaca

Figure 33. Paraphimosis in a camel. a) before treatment, b - c) treatment with bandaging and emollient creams then suture in place, d) penis 7 months after treatment

Figure 34. Preputial ring for prevention of masturbation in dromedary camels

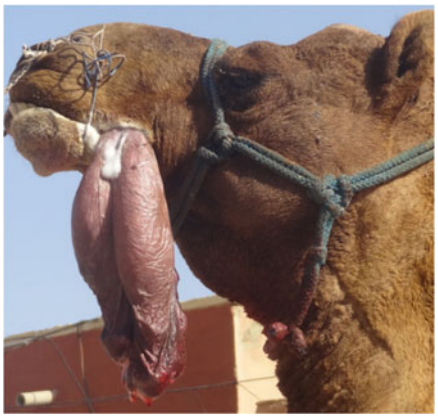

Figure 35. Traumatized permanently exteriorized soft palate in a dromedary (Courtesy of Dr. T. Mahendra [51])

Figure 36. Rectal prolapse in a dromedary camel caused by excessive mating

Figure 37. Exteriorization of the penis and attempt to flush uroliths following catheterization of the urethra

Several surgical approaches have been attempted in alpacas and llamas, including urethrotomy, bladder marsupialization, tube cystotomy, and penile reefing.[58] Tube cystotomy technique is similar to that used in small ruminants on the anesthetized patient in dorsal recumbency using a paramedian approach. After exposure of the bladder, an incision is made into the bladder wall and the uroliths are removed followed by flushing of the urethra. A Foley catheter (12 - 18 Fr) is placed through a stab incision in the body wall of the inguinal region, inserted into the bladder and sutured in placed using a purse string suture (Figure 38). The cystotomy incision is closed using an inverting suture pattern.

In camels, urethrotomy is the most common salvage procedure.[60] However, a case of successful management with tube cystotomy was recently described in a Bactrian camel.[61] Overall, these surgeries carry a poor prognosis, particularly for reproduction.

Figure 38. Tube cystotomy in a llama

Conclusions

Surgical interventions on the urogenital systems are common in camelid practice. Veterinarians providing theriogenology services should be trained for a wide range of reproductive surgeries. Most of the surgical techniques are similar to those practiced in other large domestic animal species. However, case management should take into account anesthetic management and species anatomical differences. As data continue to accumulate on postoperative care and possible complications, veterinarians can provide better assessments when communicating with clients.

Conflict of interest

There are no conflicts of interest to declare.

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