Diagnosis and treatment of reproductive diseases in Camelidae is rapidly becoming a major part of the veterinary care provided to the Camelidae industry especially when dealing with genetically superior animals. Reproductive diseases and infertility in the female can be placed in one of 4 categories of complaints.

1. Failure of the female to become pregnant (Repeat Breeding Syndrome);
2. Failure to maintain pregnancy after breeding and conception (early embryonic death, fetal loss or abortion);
3. Failure to complete breeding because of physical or behavioral problems (intromission difficulties, refusal of the male);
4. Observed abnormalities in the genitalia (abnormal conformation or lesions of the vulva and perineum, abnormal vaginal discharge, etc.)

Ovulation failure after adequate mating may be a cause of repeat breeding in Camelidae. Ovulation rate in a well managed herd ranges from 80 to 90% [1,2]. Ovulation failure may be caused by inadequate LH release in response to copulation [1,3]. This lack or insufficient LH release could be due to a hypothalamo-pituitary function disturbance or to a reduced stimulatory effect of copulation. It has been shown in the Bactrian camel that some males have low fertility because they tend to achieve lower ovulation rates than others [4]. It was suggested that in these cases, there is a reduced potency or concentration of a GnRH-like factor present in semen that causes ovulation [5]. Similar trends were observed in alpacas by the author.

Factors that interfere with ova transport in the bursa (i.e. bursitis) and uterine tube (i.e. salpingitis; occlusions) or impair semen viability and transport (uterine adhesion, endometritis, obstruction of the utero-tubal junction) may be the cause of repeat breeding. Inability to complete copulation is a frequent cause of fertilization failure. This is due to either lack of intromission or partial intromission without ejaculation. Difficulties in intromission are encountered in presence of vaginal or vestibular anomalies (i.e. partial or total adhesions or persistent non-perforated hymen) or discrepancies in size between the male and female [6].

Early embryonic death in the dromedary is usually between 8 and 32% depending on the rearing conditions [6]. Most of the pregnancy wastage due to early embryonic loss occurs before Day 45 and therefore go unnoticed in the llama and alpaca. The reason for such a high incidence of embryonic mortality in Camelidae is not clear. Earlier reports have suggested that the side of ovulation may have an effect since all pregnancies are carried on the left horn, but it is well established now that maintenance of pregnancy is equal whether the ovulation occurred on the left or the right ovary [2]. Some of the possible etiologies of embryonic death in Camelidae include genetic or environmental factors, corpus luteum dysfunction and uterine pathology such as infection or fibrosis.

Management errors account for a high number of reported cases of infertility due to repeat breeding syndrome. In a study conducted in the field it was observed that 45% of all dromedary females presented for breeding had no follicular structures on the ovaries or only follicles smaller than 9-mm. Other management errors include breeding with a young male, overuse of males, lack of verification of intromission during copulation.
Accurate diagnosis of the cause for repeat breeding relies on the history of the animal and the herd; clinical evaluation of the female and laboratory findings. Initial examination should involve at least rectal palpation, ultrasonography, vaginal examination and uterine culture. Uterine biopsy would be indicated especially if there is evidence of repeated early embryo loss or abortion or if the female is old. The objective of the evaluation is to establish the normalcy of the genital tract (absence of congenital and acquired gross abnormalities), follicular development, ability to ovulate in response to breeding and development of a functional corpus luteum. Detection of ovulation and evaluation of luteal function is done by determining plasma progesterone concentrations on a blood sample taken 7 to 8 days after mating. Estrogen determination is indicated when follicular development is not observed after a series of ultrasonographic examinations [7].

**Diseases of the Ovaries and Ovarian Bursa**

Ovarian pathology and particularly ovario-bursal adhesions are responsible for a great number of long standing infertility problems in the dromedary [8].

**Cystic Conditions of the Ovary**

Cystic conditions of the ovaries are of two type: cysts within the ovary itself (ovarian cysts) such as follicular or luteal cysts and cysts outside of the ovarian tissue known as para-ovarian cysts. Although types of ovarian cysts have been described in dromedary [6,9,10] and Bactrian camels [11], the cystic ovary condition is not well documented as in cattle or other domestic animals. In fact, the term “cystic ovaries” does not always apply to Camelidae because a large proportion (30 to 40%) of females develop some form of follicular cyst if not bred given that ovulation in these species is induced [2]. Para-ovarian cysts are fluid filled structures located in the broad ligament near the ovary or uterine tube. Para-ovarian cysts could be remnants of the mesonephric (Wolfian) or paramesonephric (Mullerian) duct system. Cysts can be single or multiple, unilateral or bilateral, round or oval, measuring 0.5 to 5 cm in diameter. Their effect on fertility is not known (Fig. 1) [6].

![Figure 1. Para-ovarian cysts. These structures can be large enough to be visualized by ultrasonography and have the appearance of a follicle. It is important to differentiate para-ovarian cysts from oviductal enlargements (hydrosalpinx) (O = ovary).](image1)

Ovarian cysts are described according to the structure involved and their appearance. Cysts are classified as follicular cysts, luteal cysts, cystic corpora lutea or hemorrhagic cysts according to their histological and physical characteristics [12]. Only follicular cysts have been described in Bactrian camels and are associated with infertility [13].

Follicular and hemorrhagic cysts are a normal evolution of the non ovulatory follicle in 30 to 40% of females [1,2,14]. Cystic conditions of the ovaries are easily diagnosed by ultrasonography (Fig. 2). They can be single or multiple. They can be as large as 12 cm in diameter and can weight as much as 250 g [2]. Hemorrhagic cysts have a thicker wall than follicular cysts and have a peculiar echo-texture resembling a hematoma (Fig. 3). Luteal cysts are usually single, thick-walled, grayish-yellow and smaller in size than follicular cysts. They originate from luteinization of follicular cyst. These luteal cysts are relatively easy to identify by ultrasonography. Endocrinological behavior of ovarian cysts in camelids has not been studied in detail. Estrogen and progesterone content in the cystic fluid of two specimens revealed levels of 406.6 and 458.1 pg/ml and 47.8 and 65 ng/ml respectively [9].

![Figure 2. Ovarian Cysts or Anovulatory Follicles. These structures are relatively common in non-bred females. (Top: large ovary with an anovulatory follicle of 5 cm in diameter, bottom: typical ultrasonogram of an anovulatory follicle).](image2)
Figure 3. Hemorrhagic Follicle/Cyst. Gross (top) and ultrasonographic (bottom) appearance of a hemorrhagic follicle. These structures can persist for several weeks and may develop enough luteal tissue to produce progesterone.

The standard therapeutic approach to this condition by the author is to first induce luteinization with hCG (human Chorionic Gonadotropin) (5000 to 10,000 IU) followed 8 days later by an injection of PGF2α or its analogue. Injection of PGF2α or its analogue may need to be repeated 24 hours later. Females that have the tendency to develop anovulatory follicles because of failure to ovulate should be given hCG after breeding.

**Ovarian Inactivity**
Absence of ovarian follicular activity is a frequent condition in *Camelidae*. Absence of follicular activity can be due to congenital or acquired ovarian hypoplasia. Ovarian activity is greatly affected by body condition, lactation and use of the animal. Ovarian activity is reduced in females just retired from racing and in females with a low body condition score (< 3). Ovarian hypoplasia due to genital or chromosomal abnormalities is also possible [7]. Clinical diagnosis of ovarian inactivity or hypogonadism is based on findings at rectal palpation, ultrasonography and endocrine profiles. The ovaries are very small, usually half to one third of the normal size, and hard with a smooth surface. Ovarian hypoplasia should be suspected if estradiol levels remain very low. A definite diagnosis of ovarian hypoplasia can be reached by laparoscopic evaluation.

**Persistent Corpus Luteum**
Persistent corpora lutea are rare in the female *Camelidae*. However, the condition has been suspected on the basis of prolonged elevated plasma progesterone levels in the absence of pregnancy [15]. In the author’s experience, persistence of luteal function (high progesterone concentrations) is rarely due to maintenance of the corpus luteum but rather to the luteinization of hemorrhagic follicles.

**Ovario-bursitis**
Ovario-bursitis is a peculiar affection of the ovarian bursa characterized by the accumulation of variable amounts of fluid and encapsulation of the ovary (Fig. 4) [6,8]. The condition is suspected when difficulty is encountered during retraction of the uterus and ovarian palpation. In some cases, the oviduct presents a severe torsion easily identified by palpation. The Ultrasonographic appearance of the ovarian-bursa and its contents is variable and depends on the size, ovarian activity and the nature of the fluid within the bursa. (Fig. 5).

Figure 4. Ovario-bursitis. Accumulation of large quantities of fluid within the ovarian bursa. Note that this tract also shows evidence or peri-uterine adhesion and salpingitis of the left side (arrows) (OBP, Right side).

Figure 5. Ultrasonogram showing fluid within the ovarian bursa (ovariobursitis). (OBP= fluid within the ovarian bursa, O= Ovary, U= uterine horn).

The etiopathogenesis of this condition is not well understood but could involve bursal adhesions, uterine infection or predisposing genetic factors [6]. The condition could be due to chronic infection involving *Campylobacter* or *Brucella* [16]. Reproductive life can be saved in the case of unilateral affections by surgical removal of the affected bursa and ovary [8,17].
**Ovarian Tumors**
Ovarian neoplasms do not constitute a major cause of reproductive problems in *Camelidae* [6,9,18]. Most of the reported ovarian tumors are teratomas. They are benign and do not seem to have any effect on follicular activity on the contralateral ovary. The ovarian mass presents different types of tissues including cartilage, bone and hair (Fig. 6). Dysgerminoma has been reported in the dromedary camel but is extremely rare [10].

![Figure 6. Teratoma: Note presence of hair, cartilage and bone within the ovary.](image)

**Inflammatory Disorders of the Ovaries**
Inflammation of the ovaries (Oophoritis or Ovaritis) may be secondary to a peritonitis or perimetritis. It is characterized by loss of follicular activity because of the presence of adhesions between the ovarian surface and the surrounding tissues including the ovarian bursa, uterine tube and sometimes extending to include some intestinal loops. Diagnosis of this condition is based on palpation and ultrasonography. Exploratory laparotomy or endoscopy confirms the diagnosis. Ovarian inflammation and adhesions can also result from hemorrhage due to harsh manipulation of the ovaries or attempts to rupture anovulatory hemorrhagic follicles. Chronic localized inflammation of the ovary accompanied by abscess formation near the ovary has been observed in a few cases [6].

**Diseases of the Uterine Tube (Oviduct)**
The most dominant pathology of the uterine tube in *Camelidae* is inflammation with occlusion or accumulation of fluid in the form of pyosalpinx or hydrosalpinx. Rectal palpation and ultrasonography help in the diagnosis of these enlargements of the uterine tube (Fig. 7). In severe cases, the ovary and ovarian bursa may be involved and adhere to each other. However many uterine tube inflammations or occlusions are not noticed clinically. The fertility prognosis in these cases is guarded to poor because there is no specific treatment. Surgical ablation in unilaterally affected animals may be considered if the other side is patent [6].

![Figure 7. Hydrosalpinx. Dilation of the uterine tube due to accumulation of fluid. In this case the dilation is limited to only region of the uterine tube.](image)

Other uterine tube pathologies found in the dromedary include mucosal cysts. Inflammatory changes can also be seen at the level of the uterine tubal junction (uterine tube papillae) with development of microabscesses. Diagnosis of this condition is not easy and requires videoendoscopic evaluation of the uterine tube papillae, induction of superovulation and embryo collection or laparoscopic examination. Prognosis for all these conditions is poor if bilateral and at best guarded if unilateral [6].

**Diseases of the Uterus**
The uterus of *Camelidae* is the site of congenital or acquired abnormalities. Amongst the most common congenital abnormalities of the uterus reported in *Camelidae* are segmental aplasia, uterus unicornis and infantilism. The acquired abnormalities of the uterus are dominated by inflammatory and infectious conditions (metritis or endometritis). Segmental aplasia represents the lack of development of parts of the tubular system of the genitalia. Occurrence of the aplasia in the posterior part of the tubular genitalia (from the cervix to the hymen) is usually detected by the presence of an enlarged uterus due to fluid accumulation in the organ (cf. pyometra/mucometra) (Fig. 8).

![Figure 8. Ultrasonogram of a dense mucometra due to segmental aplasia.](image)

Uterine infections are the most common acquired reproductive problems resulting in infertility [6,16]. In
most females, the initial contamination of the uterus is swiftly dealt with and eliminated by the natural defense mechanisms present in the uterus. However, in a proportion of the females these mechanisms will fail completely or partially allowing establishment of the infection. No studies have been carried out concerning uterine defense mechanisms in Camelidae but they are likely to be similar to what is known in other species. Uterine infection should be suspected in any animal with a history of repeat breeding or early embryonic death. Diagnosis is confirmed by the results of clinical examination. Examination of the perineum and vulva may reveal mucopurulent discharge. In some cases, the base of the tail may present dried flakes of vaginal discharge. Rectal palpation and ultrasonography may in some cases reveal a thickened uterine wall and various amount of fluid. Diagnosis is confirmed by vaginoscopy, uterine culture, uterine cytology and eventually uterine biopsy. Uterine biopsy is an important part of the evaluation of the barren female because it allows a better evaluation of the extent of the inflammation (degree of infiltration), its duration (chronic or acute) and the extent of irreversible changes occurring in the endometrium [7].

Uterine culture yields a wide variety of non specific micro-organisms including; Corynebacterium pyogenes, E. coli, β-haemolytic Streptococci, Staphylococcus sp., Klebsiella pneumoniae, Aspergillus spp., Mucor sp. [16]. All these organisms are ubiquitous making uterine culture results misleading if not interpreted correctly and correlated to clinical, cytological and histopathological findings. Campylobacter fetus has been isolated from the uterus of many barren dromedary females and merits further studies [19]. There are no clinical trials comparing the efficacy of different treatments for endometritis in Camelidae. Most practitioners use the usual treatments proposed for the bovine or equine species. Local treatment consists of uterine lavage or infusion with weak antiseptic or antibiotic solution. Uterine infusion with antiseptic solutions is progressively abandoned in favor of infusion with an antibiotic solution. The efficacy of this treatment depends on the nature of the antibiotic used, the volume infused and frequency of infusion. The procedure followed by the author for the treatment of endometritis consists of a pre-treatment lavage of the uterus with a phosphate buffered solution containing penicillin, followed by either daily intrauterine infusion of penicillin for 3 days or a systemic treatment with an association of trimethoprim and sulfamethoxazole daily for 5 to 7 days. Post-treatment breeding management is important to reduce the risk of re-infection. The author advises to monitor ovarian activity and timed breeding. Prevention of uterine infection requires a good breeding management in maiden and susceptible females and strict code of hygiene during breeding and parturition.

Pyometra and mucometra are conditions characterized by an enlargement of the uterus due to accumulation of varying quantities of fluid (a few milliliters to several gallons). Pyometra with an open cervix and vaginal discharge is observed primarily in the puerperium period and is due to a postpartum complication (retained placenta, dystocia, uterine prolapse) resulting in delayed involution due to infection and accumulation of fluid. Closed cervix pyometra is the most prevalent in Camelidae and is usually associated with cervical adhesions or prolonged progesterone therapy. All cases of pyometra that I have diagnosed were associated due to cervical or vaginal adhesions or to prolonged progesterone treatments. Pyometra and mucometra are easily diagnosed by rectal ultrasonography of the uterus. Other uterine diseases resulting in infertility in Camelidae include, uterine cysts, uterine abscess, peri-uterine adhesions, serosal abscess, polyps and uterine neoplasm [6]. Multiple or single uterine cysts can be diagnosed easily by ultrasonography and fibroscopic examination of the uterine cavity. Cysts can also be encountered on the uterine serosa or in the broad ligament and have usually no effect on fertility if they are small. Uterine abscesses are due to the presence of a lesion in the wall of the uterus usually caused by rough manipulation of a uterine pipette, complication of a cesarean section or at parturition. Lesions can be palpated as a nodule or visualized by ultrasonography [6]. Periuterine adhesions are suspected when difficulty is encountered while attempting to retract the uterus at rectal palpation. Adhesions are usually a consequence of peritonitis [6]. Uterine neoplasias are rare in Camelidae.

Diseases of the Cervix
Examination of the cervix is very important for the evaluation of the infertile animal as well as for the evaluation of physiological states such as prepartum dilation and postpartum involution. Congenital anomalies of the cervix, due to abnormal development of the mesonephric and paramesonephric ducts, lead to the formation of cervical cyst or segmental aplasia. The most common abnormality of development of the paramesonephric ducts is the persistence of its medial walls giving rise to the formation of a double cervix (Fig. 9) [6].
The most common acquired pathological conditions of the cervix are due to local inflammation (cervicitis) or injuries during parturition or gynaecological manipulations. Cervicitis is usually associated with uterine infections and vaginal mucopurulent discharge. The condition is easily diagnosed by speculum examination. Cervicitis should be differentiated from the normal hyperemia and slight irritation found immediately following breeding. Other acquired anomalies of the cervix include cervical adhesions or lacerations resulting from a complication of birth or excessive trauma during manipulation.

Diseases of the Vagina and Vulva
Several abnormalities of the vagina and vestibulum have been reported in Camelidae including segmental aplasia, persistent hymen, vaginal constriction, and presence of vaginal septum. These anomalies should be suspected when there is difficulty in penile intromission. Persistent hymen can be resolved by manual dilation of the vestibulum or by surgical incision. Inflammation of the vagina (vaginitis) is relatively common and associated with bad management of breeding or inadequate manipulation of the vaginal cavity. These inflammations are usually noticed in the form of traumatic vaginitis following a difficult birth. The vaginal mucosa appears bruised and hyperaemic, sometimes there is a mucous secretion. Coitus can also induce traumatic injuries especially if the female is still young. Traumatic injuries of the vagina can lead to the formation of complete adhesions between the vaginal wall and development of pyometra. Vaginal prolapse occurs in Camelidae during pregnancy.

Diseases of the Pregnant Female
The most prevalent disorders during pregnancy are embryonic death, abortion, vaginal prolapse and uterine trauma. In the dromedary, reported abortion rates range from 2 to 11% [6]. Various infectious, traumatic or toxic factors have been associated with abortion in Camelidae. However, the part that each of these factors play in the incidence of abortion is largely unknown. In the dromedary, suspected causes of abortion include non-specific uterine infections, brucellosis, toxoplasmosis, trypanosomiasis, twining (Fig. 10) as well as stress and abdominal trauma. Abortion in the female dromedary has been associated with hemorrhagic disease and severe hemorrhagic necrotising placentitis accompanied by edema [20]. Abortion in llamas and alpacas has been associated with toxoplasmosis, *Chlamydia* and *Piroplasma*. Iatrogenic abortion can occur following administration of prostaglandin F2 alpha or its analogues or anti-inflammatory steroids.

Vaginal prolapse occurs during the last 2 to 3 months of pregnancy. It is probably due to softening of the tissue resulting from increased estrogen concentration during the last part of pregnancy. Most of vaginal prolapses concern older females and females in very good body condition. The prolapsed vagina is sometimes limited (3 to 5 cm) and visible only when the female is in the sitting position. However, with increased inflammation and edema of the tissue, the prolapsed part of the vagina increases in size and becomes permanently exteriorized. Prolonged periods of prolapse lead to increased inflammation of the prolapsed tissue and even severe necrosis of the vaginal mucosa (Fig. 11). The prognosis for the life of the fetus and dam is relatively good if the condition is treated early. Treatment consists of replacing the prolapsed part of tissue after cleaning it with a mild antiseptic solution or physiological saline and maintaining it in place with a vulvar suture (Buhner method) [6].
Figure 11. Vaginal prolapse is relatively common in the last trimester of pregnancy in camelids (a). The prolapsed vagina should be cleaned, replaced and maintained in place by a purse string suture (b,c) (Buhner suture).

Uterine Torsion
Uterine torsion has been described in all camelids. Most of these torsions are clockwise (right) and can be complete (380°) or partial (90, 180 or 240°). This affection is considered by some authors as the leading cause of dystocia and cesarean section in Camelidae [6]. The female is usually presented after unsuccessful and long first stage of labor, accompanied by signs of abdominal discomfort including frequent sitting and rising up, rolling and self-auscultation. Some highly stressed dromedaries may develop diarrhea. The prognosis of uterine torsion is good for both the dam and fetus if diagnosed and treated early. Dromedary cases are corrected manually after laparotomy followed by cesarean section if the dam is near term. Correction in llamas and alpacas can be successfully accomplished by rolling [21].

Uterine Hemorrhage and Rupture
Uterine hemorrhage is relatively rare during pregnancy unless accompanied by rupture of the uterus due to torsion or other birth complication. Uterine rupture in the dromedary may be followed by prolapse of the uterus and severe hemorrhage due to rupture of the major uterine blood vessels. The prognosis in such cases is usually poor and humane euthanasia is warranted.

Fetal Maceration
Fetal maceration has been described in the dromedary camel but the exact etiology of these cases remain unidentified [22,23]. Diagnosis is made following palpation and ultrasonography of the uterus. The entire fetus may still be present in the uterus in some cases but in other case only the fetal bones are detected by rectal palpation, ultrasonography [6]. Maceration could be due to an incomplete abortion where the fetus fails to be expelled because of the lack of uterine contractions or insufficient cervical opening. The uterine cavity may become infected leading to an autolysis of the fetus. In both reported cases no signs of illness were observed in the females.

Diseases of the Postpartum Period
The most common disorders of the reproductive tract in the postparturient camelid are retained placenta, postpartum metritis and uterine prolapse. In the dromedary, delivery of the placenta can take up to 12 hours with no effect on the dam. The incidence of retained placenta is increased following dystocia and cesarean section. Most cases of retained placenta are due to uterine inertia. In some cases, a retained placenta may require manual removal. The placenta removed in this manner should be spread to verify if it is complete. In the case of partial retention of the placenta or evidence of placentalitis, an antibiotic treatment should be given as soon as possible to prevent development of septic metritis. Other treatments for retained placenta used in equines include distention of the uterus with warm, dilute povidone iodine solution or injection of oxytocin (30 to 40 IU IM) to promote uterine contraction.

During the postpartum period, the uterus is exposed to bacterial contamination. Prevention of postpartum metritis can be achieved by regular monitoring of the periparturient female, hygienic conditions during parturition and early and efficient obstetrical manipulation if needed. Any manipulation of the genital tract should be followed by local or systemic prophylactic antibiotic treatment. All postparturient females should be monitored for signs of fever or septicemia for the first 5 days postpartum.

Uterine prolapse occurs as a complication of parturition especially after dystocia, retained placenta or excessive obstetrical manipulation. Uterine prolapse occurs in old females with excessively relaxed vagina and pelvic ligaments. The prognosis depends on the extent, the state of the uterine tissue and presence of other complications such as toxic shock and ruptured uterine blood vessels. The prognosis is poor if there is evidence of uterine blood vessel rupture, lacerations or necrosis due to prolonged exposition of the uterus to the harsh environment (cold or sun). Replacement of a complete uterine prolapse in the female dromedary is very challenging and requires use of sedation (Fig. 12) [6].

Perineal or recto-vaginal lacerations occur because of pressure of the fetal forelimb or forceful traction of the fetus (Fig. 13). Perineal laceration does not necessarily affect the fertility of the female if the vestibular sphincter is preserved and prevents entry of fecal material into the vagina. However, mating should be carefully monitored in order to prevent intromission of the penis into the rectum. To prevent these problems surgical repair should be attempted when the wound has healed and swelling and granulation tissue have subsided.
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