Uterine infections in Camelidae

Professor Ahmed Tibary

Department of Veterinary Clinical Sciences, College of Veterinary Medicine, Washington State University, Pullman WA 99164-6610; tibary@vetmed.wsu.edu

Professor Abdelhaq Anouassi

Veterinary Research Centre, PO Box 77749, Abu Dhabi, United Arab Emirates; vetrsrch@emirates.net.ae

Introduction

Poor reproductive efficiency has been described as a major problem in camelids. Alpacas have a mean annual fertility of 50% [5], and llamas a mean birth rate of 46% [3]. Low fertility in alpacas is probably due to the high (50 to 58%) embryonic loss before 30 days of gestation [1]. In the camel, the reproductive rate varies between 25% and 80% depending on the level of management and veterinary care provided [20].

Various uterine disorders have been described in camelids and may play an important role in reduced fertility in these species [19]. Like so many domestic animal species, uterine infections are the most common of these disorders [6, 9, 13, 19, 22, 26, 27], but unlike other species, little is known about their pathogenesis and evolution in camelids. Consequently, many practitioners approach the diagnosis and treatment of endometritis in female camelids in the manner described for cows and mares. The present paper discusses the etiology, diagnosis and treatment of uterine infection in camelids.

Predisposing factors

During the reproductive life of a female the uterus is exposed to the risks of infection, particularly at the time of breeding and following parturition when various microorganisms are carried from the posterior part of the genitalia or from the environment into the uterine cavity. In most cases, the initial contamination will be eliminated by the natural uterine defence mechanisms. However, in a proportion of females partial or complete failure of these mechanisms allows the establishment of an infection. So far, no studies have been carried out on uterine defence mechanisms in camelids, though they are likely to reveal similarities to those in other species. Local immunity, phagocytosis and mechanical clearance by myometrial contractions are the major mechanisms used to clear uterine infection, and are more effective during the follicular phase of the oestrous cycle, when estrogens are high and the uterus has maximal contraction [19]. Failure of these defence mechanisms leads to the establishment of a uterine infection and the development of an endometritis or metritis, and usually occurs when uterine resistance is diminished due to degenerative changes in the endometrium (fibrosis) or repeated heavy infection with pathogenic microorganisms.

In the author's experience, the most significant factors contributing to uterine infections in camelids are overbreeding (i.e. excessive matings during the period of receptivity), postpartum complications and unhygienic gynaecological examination and manipulation. During mating, the penis penetrates the cervical canal and in some cases enters deep into the uterine cavity. Repeated microbial insults to the uterus impair its ability to fight infection. Many breeders not familiar with the reproductive physiology of female camelids rely exclusively on 'receptive' behaviour for breeding. However, studies have shown that receptivity is not necessarily correlated with ovarian activity [16, 21], and this method leads to multiple matings that have little chance of success and instead may cause damage to the endometrium and cervix [18, 21]. Preliminary analysis of alpacas that had been referred to the author because of infertility problems, shows that the average number of matings per breeding season (generally a period of 20 to 40 days) before referral was 8.5, with a between mating interval of 3.2 days.

Diagnosis and etiology

Establishing the cause of infertility in any species relies on knowing the full breeding history of the patient and performing an extensive examination of the reproductive tract. The latter should include a general physical examination, palpation and ultrasonography of the reproductive tract and vaginoscopy. Uterine swabs should also be collected for cytology and bacteriological culture, as well as an endometrial biopsy sample to evaluate pathological changes in the endometrium [17].

History and Clinical Signs

Uterine infection is highly likely to occur in any animal with a history of repeat breeding, early embryonic death or abortion. The barren female with endometritis or metritis may have a history of recent abortion, retained placenta, dystocia or uterine prolapse. While systemic signs are usually absent for endometritis, fever, depression and signs of toxic shock may accompany acute postpartum metritis. In these cases, supportive treatment should be started immediately. External clinical signs may suggest the presence of an infection, for example heavy mucopurulent discharge around the perineum and vulva (Figure 1), and dried flakes of vaginal discharge at the base of the tail. While a thick, pinkish or white discharge (lochia) is normal in the postpartum female, and may persist for up to one week after parturition, a profuse, watery or smelly discharge should be considered abnormal and a sign of postpartum metritis. When evaluating the barren female, conformation of the vulva and perineum are very important. An incompetent vulva or vestibulo-vaginal sphincter, resulting from tears or laceration, may be the primary cause of vaginal and uterine contamination (Figure 3). Excessive vulval oedema may be associated with overbreeding but can also result from excessive oestrogen therapy (Figure 4).

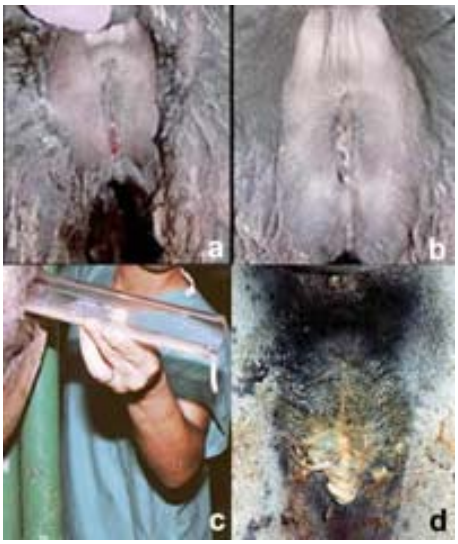


Figure 1. Mucopurulent vaginal discharge from llamas (a and b) and dromedary camel (c and d).

.

Figure 3. Abnormal perineal conformation. Rectovaginal tear in a llama (a) and dromedary (b) with uterine infection. A large amount of faecal material was recovered from the vaginal cavity of the llama.

Figure 4. Typical swelling of a llama's vulva due to overbreeding or excessive oestrogen treatment.

Palpation and ultrasonography

The primary goal of this examination is to rule out pregnancy and to establish the normal size, consistency and content of the uterus. Per rectum palpation and ultrasonography, can reveal changes that are consistent with a uterine infection. For instance, a delay in uterine involution in the postpartum female, a process that is usually complete by 15 days in llamas and alpacas and by 25 days in camels, is suggestive of uterine infection. Likewise, ultrasonographic visualization of a thickened uterine wall and excessive dilation of blood vessels may also suggest the presence of a uterine inflammation (Figure 5). In the absence of pregnancy, any amount of free fluid in the uterine cavity should be considered with suspicion – a uterine infection or clearance problem usually being the cause. Pyometra is usually seen in the immediate postpartum problem females, or in presence of vaginal and/or cervical adhesions (Figure 6) [19, 22]. Transrectal ultrasonography combined with uterine flushing offer a better method to visualize echogenic intraluminal material, adhesions or abscesses, and to evaluate the uterine wall (Figure 7).

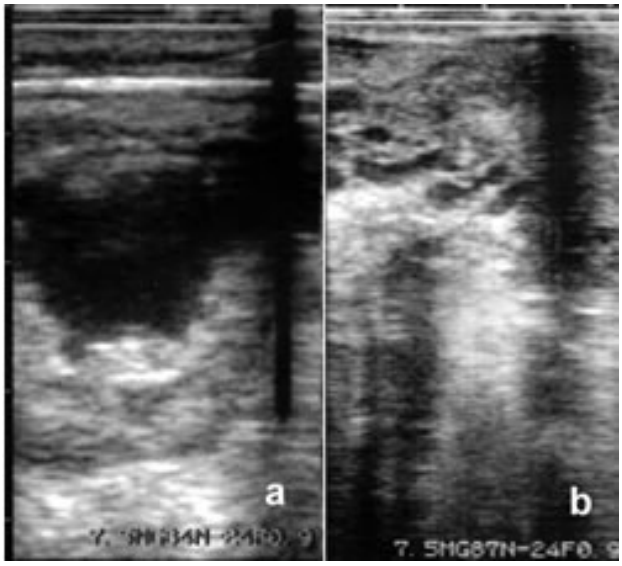
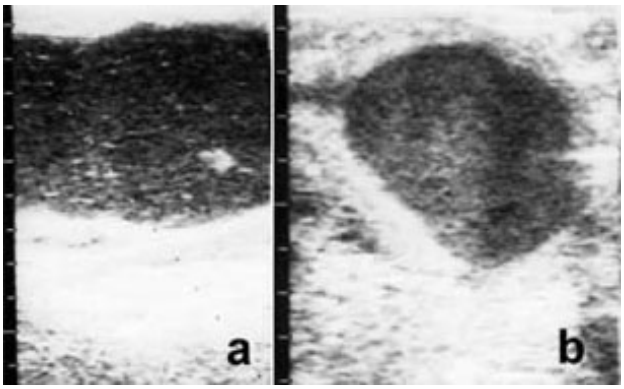


Figure 5. Ultrasonographic appearance of endometritis in an alpaca with accumulation of fluid (a) and dilation of the uterine veins (b). Note the thickened uterine wall in (a).



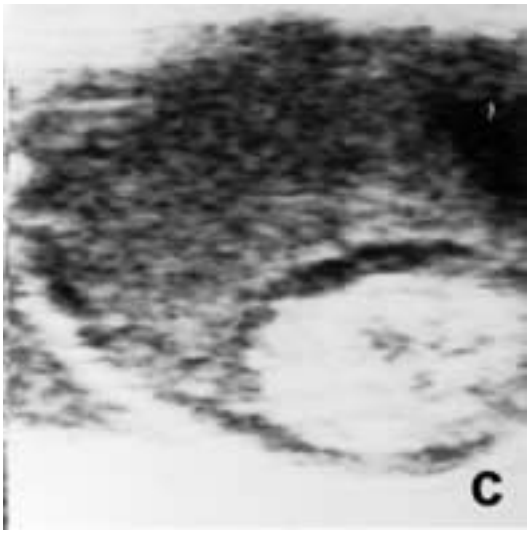


Figure 6. Ultrasonographic appearance of pyometra. Note the composite fluid in all cases. Image c) shows the remnants of a fetus.

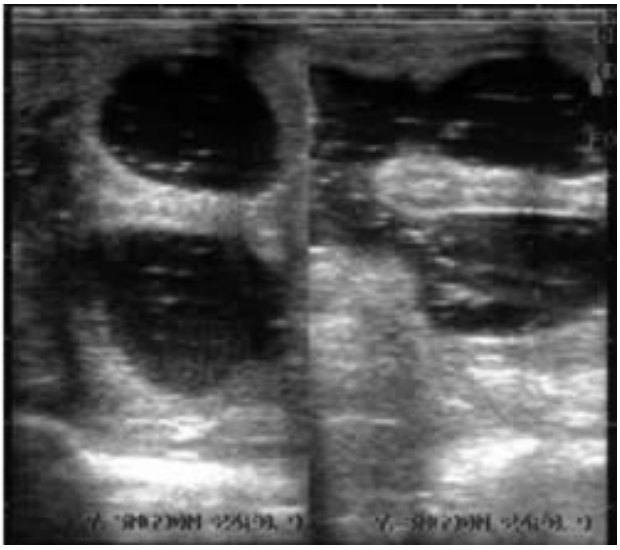


Figure 7. Ultrasonographic evaluation of the uterine cavity during flushing in an alpaca. This technique allows better visualisation of the endometrial lining. Note the intercornual septum on the right side.

Vaginoscopy

Examination of the vaginal cavity and cervix is an important step in the diagnosis of uterine infection. In the dromedary and Bactrian camel, a bovine or equine tube vaginoscope can be used, but for the smaller llama a small (3 cm) diameter mare speculum is more appropriate [17], and for examination of alpacas the author routinely uses a sigmoidoscope (Figure 8). Vaginoscopy should be done carefully in all cases that exhibit a bloody discharge or have suspected vaginal adhesions.

Figure 8. Vaginal examination using a sigmoidscope in an alpaca.

The vaginal cavity should be evaluated for evidence of inflammation or traumatic lesions. Small quantities of thick mucus may be present in the anterior vagina, although not all mucus discharge should be considered a sign of endometritis. The cervix should also be evaluated for signs of inflammation (cervicitis) and discharge (Figure 9). Under normal circumstances the cervix may be hyperaemic and bleed immediately following mating.

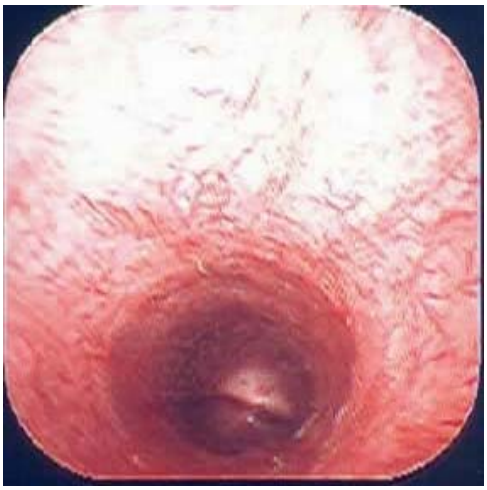


Figure 9. Vaginitis and cervitis in a maiden alpaca due to overbreeding.

Uterine cytology

Cytological examination of uterine content is a rapid and cheap way to verify the nature of any fluid present and to determine the presence of inflammatory cells. The technique should be performed after taking a uterine swab for microbiological evaluation. Cytology samples are taken from the uterus using a direct double-guarded swab, a cytology brush or by recuperating saline solution infused into the uterine cavity.

Uterine culture and cytology samples are preferably taken when the female is receptive and the cervix is relaxed and open. In the large camelidae (dromedary, Bactrian and llama) all these procedures are performed using the rectovaginal technique used in cows. In alpacas, passage of the swab or pipette requires direct visualization and insertion into the cervix via a vaginoscope (Figure 10).

This is relatively easy to do when the alpaca has a mature follicle, thus the uterus is contracted and the cervix is open. If difficulties are encountered, a treatment with oestrogens (e.g. ECP, estradiol cypionate, 3 mg intramuscularly (i.m.) 8 to 12 hours prior may facilitate manipulation. However, this treatment may not always be appropriate as it causes excessive cervical oedema. Utilization of large doses of or repeated treatment with oestrogen should be avoided.

Figure 10. The technique used for taking a uterine swab in alpacas.

Uterine swabs should be taken after wrapping the tail and thoroughly cleaning the vulva; some individuals may require sedation for this procedure. While intravenous (i.v.) injection of xylazine works well for dromedary and Bactrian camels, a combination of xylazine and butorphanol is preferred for alpacas and llamas.

Once the sample has been taken, the swabs are rolled on a glass slides, air-dried and stained with Diff-Quik®. The uterus flushing technique is by far the best but has the disadvantage of being time consuming. The uterus is flushed with a small quantity of sterile saline using either a Foley (or balloon) catheter or a mare insemination pipette. The fluid is collected, fixed in 40% ethanol and centrifuged to concentrate the cells. Smears are prepared from the sediment, air-dried and stained with Wright-Giemsa, Papanicolaou stain or Haematoxyline and Pollack's trichrome. The degree of inflammation is assessed by an evaluation of the number and the morphology of polymorphonuclear (PMNs) leucocytes. The presence of three to five PMNs per high power field is usually significant in the diagnosis of endometritis, and the microorganism responsible may sometimes be observed in the cytology evaluation.

Uterine culture

Detection of uterine infection is very important in the prevention of venereal transmission of infection to other animals. In addition, identification of the causative germ and determination of its sensitivity to different drugs allows the practitioner to choose the most efficient treatment.

In order for the uterine culture to have a diagnostic value, the sample should be taken without contamination and processed according to sound bacteriological techniques. Bacteriological examinations can be done from direct uterine culture swabs, a fragment of uterine biopsy, cervical discharge or uterine flushing medium. However, direct uterine cavity swabbing is the most widely used of these techniques (Figure 10). To avoid contamination, the uterine culture swab should be guarded.

All samples should be refrigerated and shipped to the laboratory in special transport medium depending on the type of culture desired. Samples should be examined routinely for aerobic and anaerobic bacteria, ureaplasma, mycoplasma, as well as for fungi [14, 26]. Samples from camels should also be examined for Trichomonas sp. and Campylobacter sp. which are suspected to be responsible for fertility failure in the dromedary [24]. Bacteriological techniques should include sensitivity tests to the major antibiotics.

Interpretation of microbiological results of uterine swabs is very difficult given the wide range of bacteria that can be isolated (Table 1). Some of these germs are part of the normal vaginal flora whereas others are opportunistic and can become pathogenic if the right conditions are present.

Camelid species and type of examination	Site and method of sample collection	Microorganisms isolated	Comments	Reference
Dromedary (Slaughterhouse)	Uterine swabs	E. coli, micrococci, corynebacteria, Sarcina, Strep. zymogenes, anthracoids, Proteus spp., Strep. durans, C. pyogenes, citrobacter, Staph. aureus, Gaffkya, Pasteurella multocida, Staph. epidermidis, moulds	It is suspected that many of these microorganisms were contaminants	Laila Ali, 1987 [10]
Dromedary (Slaughterhouse)	Uterine swabs	M. pyogenes, C. pyogenes, Ps. aeruginosa, Staph. albus, H. strep.	Microorganisms isolated from an animal with endometritis and pyometra	Nawito, 1967 [12]
Dromedary (Slaughterhouse)	Uterine swabs	Proteus spp., Serratia, enterobacter, Kl., E. coli, enterococci, anthracoids, C. renale, Staph. aureus, micrococci, Strep. pyogenes	Dromedaries with endometritis	Hegazy, 1979 [8]
Dromedary (Slaughterhouse)	Uterine swabs	Staph. epidermidis, M. luteus, M. roseus, Pr. morganii, Staph. caseolyticus mixed with B. anthracoides, Pr. stuartii, unidentified corynebacterium.	From apparently healthy uteri. 64% yielded bacterial growth	Enany et al., 1990 [4]
Dromedary (Slaughterhouse)	Uterine swabs	E. coli, Strep. pyogenes, Staph. aureus, Kl. oxytoca, Ps. aeruginosa, H. somnus, C. pyogenes	Uteri showed signs of endometritis and 93% contained specific micro-organisms, listed here in order of frequency	
Dromedary (Slaughterhouse)	Uterine swabs	Corynebacteria, anthracoids, micrococci, Sarcina, Gaffkya, Gram-negative bacilli.	Microorganism-sisolated from non-pregnant and pregnant uteri. Gaffkya was not isolated from the reproductive tracts of pregnant animals.	Zaki and Musa, 1965 [28]
Llamas (Clinical examination)	Endometrial biopsy	Actinomyces pyogenes, Bacillus sp., Staph. sp., E. coli, Strep. sp., Bacteroides sp., Fusobacterium necrophorum.	Bacteriology culture results were consistent with histology findings in 18 (66.7%) llamas.	Powers et al., 1990 [14]
Dromedary (Clinical examination)	Uterine swabs	Campylobacter fetus	Animals had endometritis.	Wernery and Ali, 1989 [25]
Dromedary (Clinical examination)	Uterine swabs	Aerobic bacilli	Females without endometritis: 65% sterile samples	Wernery, 1991 [24]
Dromedary (Clinical examination)	Uterine swabs	E.Coli, Staph. aureus, Trichomonas fetus	Females with endometritis	
Dromedary (Clinical examination)	Uterine swabs	Staph. sp., Staph. aureus, Strep. sp., aerobic bacilli, diplococcus, E. coli, Clostridium sporogenes	Healthy females	Wernery and Wernery, 1992 [26]
Dromedary (Clinical examination)	Uterine swabs	Campylobacter fetus; Ps. Aeruginosa, Kl. Ozaenae, Salmonella sp., Serratia marcescens, M. sp.	Microorganism isolated from females with endometritis in addition to the species isolated from healthy females (see above)	

C. = Corynebacterium; E. = Escherichia; H. = Hemophilus; Kl. = Klebsiella; M. = Micrococcus; Pr. = Providencia; Ps. = Pseudomonas; Staph. = Staphylococcus; Strep. = Streptococcus.

Table 1. Types of microorganism isolated from the reproductive tract of female camelids

Staph. = Staphylococcus; Strep. = Streptococcus: Kl. = Klebsiella: Ps = Pseudomonas; C. = Corynebacterium; E. = Escherichia; ?H. = haemolytic?; M. = Micrococcus.

The bacteria responsible for endometritis in the camel are essentially those found in the equine and bovine species [11, 24, 26, 27]; the most common one to be isolated from camels with endometritis is Escherichia coli (E. coli). Other bacteria that have been isolated are Streptococcus zooepidemicus, β-haemolytic Streptococci, Enterococcus, coagulase negative Staphyloccocus, Proteus spp., Enterobacter aerogenes, Klebsiella pneumoniae and Arcanobacter pyogenes [2, 4, 11, 14, 24, 27]. Pseudomonas aeruginosa, Campylobacter fetus, and Trichomonas fetus have been isolated from infertile camels and may be associated with venereal transmission and should be considered in infertility or abortion outbreaks [26]. Aspergillus spp. and Mucor sp. have been isolated from female dromedaries with endometritis.

Most of the germs isolated from uterine swabs are ubiquitous, making uterine culture results sometimes misleading if not interpreted correctly and correlated to clinical, cytological and histopathological findings. Also, chronic uterine infections may not result in a positive culture, in which cases clinical and cytological examination of the uterus are more diagnostic.

Uterine biopsy

Histological examination of a uterine biopsy is a very reliable technique for the evaluation of modifications of the endometrium, which might be due to inflammatory, degenerative, or neoplastic processes. Uterine biopsy should be considered in females failing to conceive, despite being bred to fertile males and after the occurrence of an apparently normal ovulation, and in females experiencing early embryonic loss or abortion.

The technique of uterine biopsy in camels (both Bactrian and dromedary) and llamas is similar to that used in the mare. A mare biopsy punch is inserted closed into the cervix either by direct vaginal or by rectal manipulation. The author prefers to take samples from the left uterine horn unless a specific lesion is visualized in the right horn [19].

In the case of llamas, the animal is sedated with xylazine/butorphenol and the perineal region washed with an antiseptic solution and dried with clean towels. The mare biopsy punch (forceps) is

placed into the external os of the cervix with the aid of a speculum and then manipulated into the uterus by palpation per rectum after removal of the speculum. The cervix can be opened by administration of oestradiol (2 to 3 mg) 24 to 48 hours before taking the biopsy [14, 23].

Microscopic examinaton of a stained histological section of endometrium reveals an epithelium that can be simple cuboidal, columnar, tall columnar, or a combination. Beneath the epithelium is a variably loose or dense region of connective tissue, the upper lamina propria, which should contain a few, evenly distributed, uterine glands or gland necks. Sub-epithelial haemorrhage is frequently observed. The number of endometrial glands is very variable but lower than that observed in the mare; the number increases in the deeper lamina propria, which has a less-dense connective tissue. The glandular epithelium is columnar in the superficial part and cuboidal in the deeper layers. Intussusception of epithelial cells into gland lumens is a common artifactual finding [14] (Figure 11). Some changes due to ovarian activity, especially in the presence of a functional corpus luteum, have been described. However, these changes are not relevant in the diagnosis because most uterine biopsies are taken during the follicular phase in camelids [17]. In the llamas administration of oestradiol cypionate does not affect the histological appearance of the biopsy specimen [14].

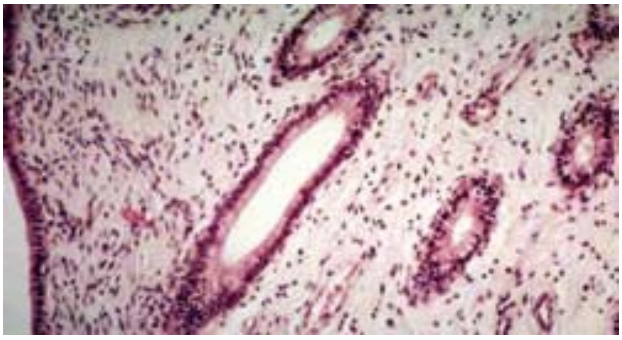


Figure 11. Photomicrograph of a section of an endometrium biopsy taken from a normal, healthy llama. Note the low number of endometrial glands.

Inflammatory changes of the endometrium are characterised by leucocyte infiltrations with different degrees of intensity and the presence of degenerative changes such as fibrosis. Inflammation of the endometrium is evaluated according to these criteria and classified into three main categories: acute endometritis, chronic infiltrating endometritis, and chronic degenerative endometritis [17].

Acute endometritis

Acute endometritis is characterised by an infiltration predominantly with polymorphonuclear leucocytes (PMNs) in the sub-epithelial zone of the stratum compactum. This endometritis can become suppurative and cause a desquamation of the endometrium (Figure 12). The exudate is composed mainly of PMNs with a small number of lymphocytes and plasma cells [15]. Sub-acute endometritis is characterised by hypertrophy and thickening of the blood vessels, the subepithelial infiltration of fibroblasts, histiocytes and lymphocytes, and by a slight leucocytic infiltration around the endometrial glands.

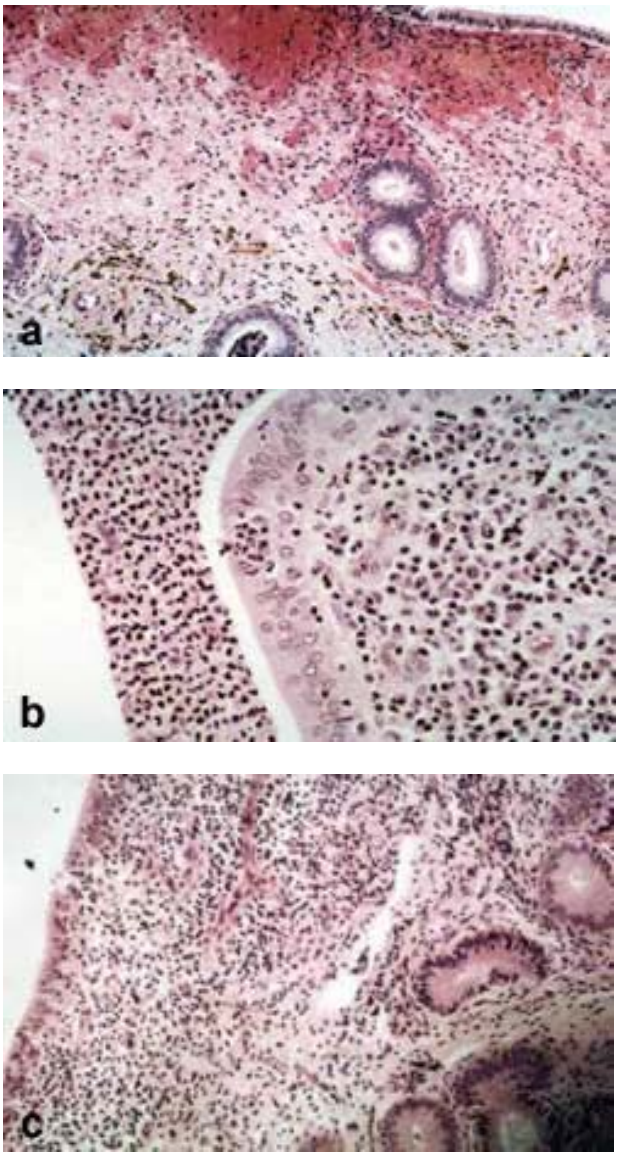
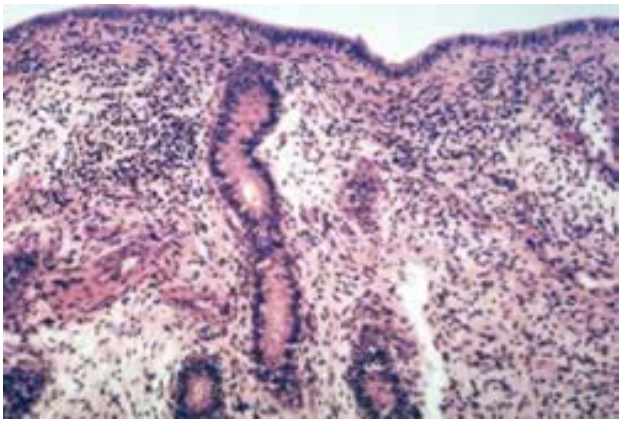


Figure 12. a) Photomicrograph of a section of an endometrial biopsy taken from a female soon after mating. Note the extent of subepithelial haemorrhage and deep siderophage. The endometrium is category Grade 2A according to the

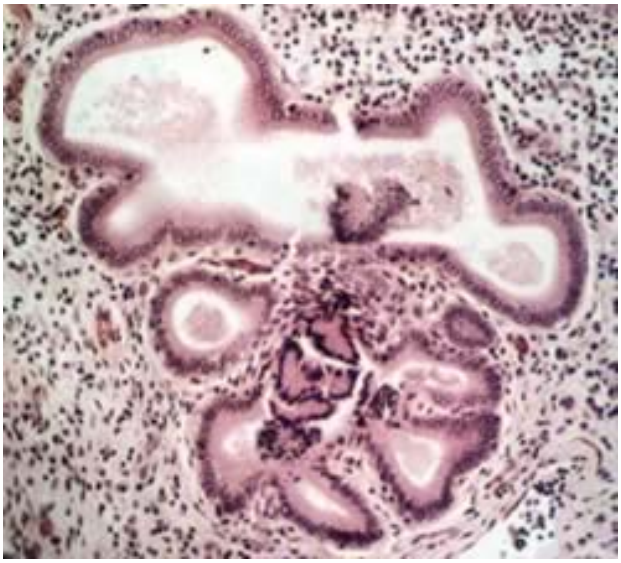
classification system adopted by Powers et al, 1990 [14].
b) Photomicrograph of a section of an endometrial biopsy taken from a female shows the presence of an acute endometritis. There was an exudate in the lumen. Note the large number of polymorphonuclear cells present in the subepithelial space. Grade 2B.
c) Photomicrograph of a section of an endometrial biopsy reveals a moderate to severe endometritis with a mixed leucocytic infiltration.

Chronic endometritis

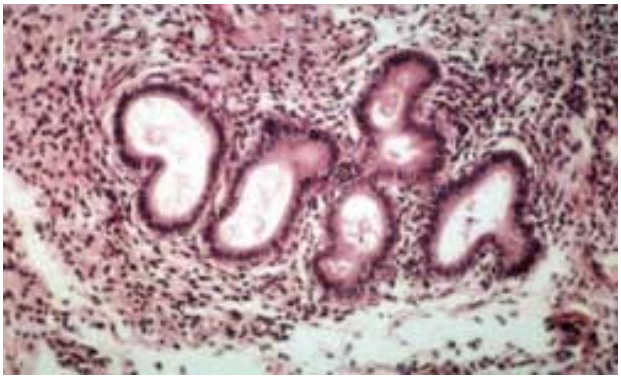
Chronic endometritis is characterised by a predominantly lymphocytic infiltration, sometimes with the presence of plasma cells, macrophages, eosinophils or mast cells. Siderophages may be present in the postpartum uterus or following abortion or embryo loss. Chronic inflammation may be localized or generalised and may involve the stratum spongiosum (Figure 13). Chronic degenerative endometritis is characterised by irreversible changes including atrophy of the endometrial glands and fibrosis (Figure 13), reduced endometrial gland diameter and secretory activity, and pyknotic nuclei in the glandular epithelia cells. These degenerative changes are due mainly to the presence of periglandular or perivascular fibrosis. In severe cases, endometrial gland nests, with with associated cystic dilation, or lymphatic cysts are observed (Figure 13). The severity of fibrosis is evaluated by the number of fibrotic layers present: slight (1 to 3 layers), medium (4 to 10 layers) and severe (> 10 layers) [14, 15].



a



b



c

Figure 13. a) Photomicrograph of a section of an endometrial biopsy showing a severe chronic endometritis. b) and c) Photomicrograph of a section of an endometrial biopsy showing chronic endometritis with periglandular fibrosis (Grade III).

A special form of chronic endometritis has been described in the dromedary camel. It is characterised by diffuse lymphocytic infiltrates and by the presence of granulomatous foci, consisting of small lymphocytes, histiocytes, and reticular cells, situated mostly in the sub-epithelial region of the endometrium. These lesions are similar to those described in cattle with campylobacteriosis or tuberculosis (Figure 14). They could also be due to fungal infection [7, 19].

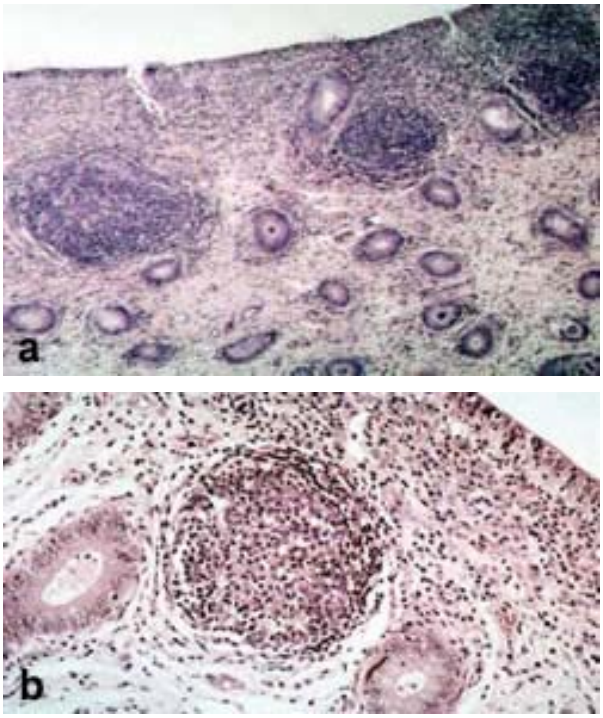


Figure 14. a) and b) Photomicrograph of a section of an endometrial biopsy from a dromedary female showing chronic lymphocytic infiltration with subepithelial granulomatous foci.

A classification system similar to that used in equids has been proposed for use in camelids, with fertility prognosis based on results of endometrial biopsies [14]. Thus, the classification adopted for dromedary endometrial biopsies includes categories (or grades) according to the type and severity of lesions observed and their potential effect on pregnancy rate and rate of embryo loss [17] (Table 2).

Categories	Characteristics	Effect on fertility	Prognosis
Grade 1A	Normal, healthy endometrium	Normal	Very Good
Grade 1B	Few lymphocytes present in the endometrium. Siderophages present postpartum or post-abortion. Low-grade infection, inflammation due to mating	Slightly decreased	Good, if treated promptly
Grade 2A to 2B	Active and acute, chronic, or chronic active endometritis. Chronic inflammation is found deeper in the endometrium than active and chronic active inflammation	Reduced conception rate. Increased early embryonic death	Good only if the pathology is recent. Poor if the female has been barren for more than one year
Grade 3A	Chronic endometritis with endometrial gland-associated fibrosis	Increased early embryonic loss and abortion	Poor
Grade 3 B	Uterine neoplasia	Not recommended	Poor, hysterectomy or euthanasia recommended

Table 2. Classification of camel endometrial biopsies according to pathological findings and their possible effect on fertility (adapted from Powers, *et al.* 1990 [14])

Treatment

Left untreated, uterine infections can lead to irreversible changes and complications such as salpingitis, resulting in a total loss of fertility [22]. There is no clinical trial comparing the efficacy of different treatments of endometritis in camelids. Most practitioners use treatments proposed for the bovine and equine species, which include uterine lavage or flushing, intrauterine antibiotic infusion, systemic antibiotic treatments or a combination of these. Intrauterine infusion of homologous blood plasma (twice at 24 hour intervals) has also been used in llamas and alpacas [9].

Uterine lavage is generally performed using warm, isotonic saline solution or a weak antiseptic solution (Figure 15). The objective of this treatment is to remove organisms and cellular debris and improve uterine clearance by promoting endometrial contraction and increased local blood flow. The ideal antiseptic solution for uterine flushing should not contain more than 1 to 3% of a 0.5% povidone-iodine solution. A lavage of the uterus with saline at the end of the treatment to remove all antiseptic from the uterus is highly recommended. Oxytocin (5 to 10 i.u. for alpacas and 20 i.u. for camels) may be given to improve uterine clearance. Uterine lavage should be carried out carefully in the case of septic endometritis to avoid complications.

Figure 15. Demonstration of uterine flushing technique using a 2-way Foley catheter in alpacas. a) equipment, b) Foley catheter insertion through a vaginal speculum using a rigid stylet, c) flushing solution, d) ultrasound monitoring during the flushing procedure.

Intrauterine antibiotic infusion is usually performed after uterine lavage and removal of all the purulent material and cellular debris (Figure 16). The choice of antibiotic depends on culture and sensitivity results. The most common antibiotics used are Penicillin K (1.5 x 10^6 units for llamas and alpaca, 5 x 10^6 for camels), Gentamicin sulfate (200 to 300 mg for llamas and alpacas, 500 to 1000 mg for camels), Ticarcillin (3 g for dromedary, particularly for Pseudomonas infections), Amikacin sulfate (2 g for camels infected with Pseudomans and Klebsiella) and Ceftiofur sodium (250 to 500 mg for alpacas and llamas, 1 g for camels). The third generation of cephalosporin, Ceftiofur, has a broad spectrum and is effective against Gram negative and Gram-positive bacteria. All these antibiotics should be diluted in saline (20 to 30 ml for llamas and alpacas, 60 ml for camels). Treatment should be daily for three to seven days depending on the severity of the endometritis as determined by biopsy.

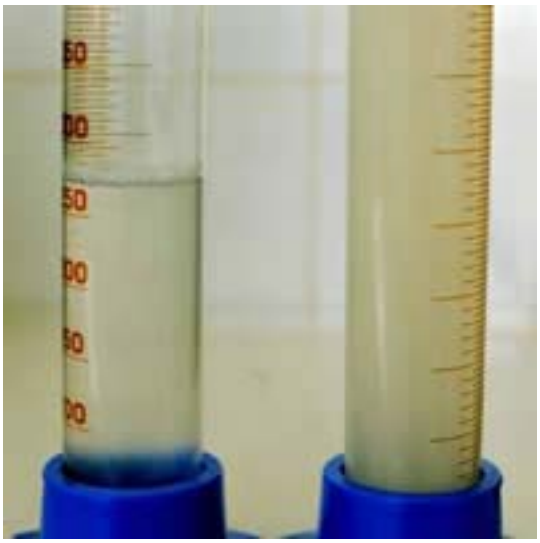


Figure 16. Uterine flushing should be continued until the flushing media becomes clear. This will enhance the efficacy of intra-uterine antibiotic infusion.

In alpaca and llama, serial intrauterine infusion may require placement of an indwelling catheter. When the uterine content is thick, it is preferable to use a 2-way Foley catheter (24 Fr. Alpaca and 30 Fr for llama). The catheter is sutured to the vulva and left in place for daily infusions; uterine flushing can be monitored by simultaneous transrectal ultrasonography (Figure 15).

The success of treatment of endometritis is variable and depends on its duration and on endometrial changes observed in the uterine biopsy. Pregnancy rates after treatment vary from 30 to 60% [14, 27]. Treated females should always be re-examined after a period of sexual rest.

Sexual rest following treatment and adoption of a 'minimum contamination breeding technique' (MCBT) will help prevent re-infection of the uterus. The rest period varies form two to four weeks depending on the severity of infection, and the adoption of a minimum contamination breeding technique requires ultrasound monitoring of ovarian activity, breeding only once when the follicle is mature followed by uterine infusion with antibiotics 24 hours following mating. In some situations it is preferable to induce ovulation using human chorionic gonadotrophin (hCG) (750 i.u. in alpaca and llamas, 1500-2000 i.u. in camels) or gonadotrophin releasing hormone (GnRH) (0.5 mg to 1 mg) or analogues (e.g. Buserelin, 4 to 8µg for llamas, 15 to 20µg for camels). Susceptible females should not be bred more than once a week. Females bred using the MCBT and induction of ovulation should be checked for pregnancy or receptivity 12 to for 14 days following mating.

Prevention

Prevention of uterine infection requires sound reproductive management practices for both the individual animal and a herd. Pre-breeding examination should be performed on all maiden animals to avoid breeding animals that are either too young or have no follicular activity. Only those females exhibiting strong receptivity (as opposed to submissive behaviour) should be bred, and detection of receptivity requires the owner to be familiar with each female's 'normal' behaviour. In hand-mating situations, breeders should be aware that aggressive males force down females even if they are not receptive. Furthermore, trained females may assume the sternal position on command by their trainer regardless of their ovarian status. This is frequently seen in racing/riding camels that are trained to respond to commands. Ideally, breeding should only take place when a mature follicle has been detected on the ovary (12 to 18 mm in camels; 8 to 12 mm in llamas and alpacas), this is particularly important for females that are susceptible to infection.

A comprehensive examination to access breeding soundness should be performed on all females with a history of infertility, obstetrical problems or postpartum complications. This allows early detection and treatment of uterine infection as well as prevention of venereal transmission to other females.

The incidence of endometritis can be reduced only if the chance of contamination of the uterus is minimized. This could be accomplished by implementing strict hygiene practices during breeding and parturition. Females should be examined for presence of uterine infection before mating, to avoid contamination of other females that are bred to the same male. In addition, parturition should take place in a clean area. If obstetric manipulations are required during birth, they should be accomplished by experienced staff after they have washed thoroughly with a mild antiseptic soap. Early treatment complications that arise during parturition, such as postpartum infection and retained placenta, will reduce the risk of irreversible damage to the uterus.

References

1. Bravo, W. and Sumar, J. (1985) Factores que determinan la fertilidad en alpacas. In: Anales de la V Convencion Internacional sobre Camelidos Sudamericanos. Organizado por IVITA de la Universidad Nacional Mayor de San Marcos y Universidad San Antonio Abad del Cusco, Peru. pp 4.

2. Chauhan, R.S., Kaushik, R.K. and Satija, K.C. (1987) The bacterial spectrum of reproductive tract of camels. J. Remount Vet. Corps. 26, 1-5.

3. Condorena, N., Sumar, J., Franco, E. and Alarcon, V. (1988) Largo de gestacion en llamas. Anales del XI Congreso Panamericano de Ciencias Veterinarias, Lima. pp 62.

4. Enany, M., Hanafi, M.S., El-Ged, A.G. F., El-Seedy, F.R. and Khalid, A. (1990) Microbiological studies on endometritis in she-camels in Egypt. J. Egypt Vet. Med. Ass. 50, 229-243.

5. Fernande- Baca, S., Hansel, W. and Novoa, C. (1970) Embryonic mortality in the alpaca. Biol. Reprod. 3, 243-251.

6. Fowler, M.E. (1998) Medicine and surgery of South American camelids : llama, alpaca, vicuna, guanaco. 2nd edn., Iowa State University Press.

7. Gimbo, A. and Zanghi, A. (1981) Su di una forma diffusa di metrite granulomatosa nella dromedaria. Rilievi isto-patologici. Schweiz. Arch. Tierheilk. 123, 249-261.

8. Hegazy, A.Y., H.I./Selim, S.A. (1979) Bacteriological and histopathological studies on endometritis of the camel. J. Egypt Vet. Med. Ass. 39, 81-97.

9. Johnson, L.W. (1989) Llama reproduction. Vet.

Clin. North. Am. Food. Anim. Pract. 5, 159-182.

10. Laila Ali, M., Shalaby, S.I.A., Shalash, M.R., Nawito, M.F. and Afify, M.M. (1987) Bacterial status of abnormal genitalia of the camels. Egyptian J. Vet. Sci. 24, 41-44.

11. Nawito, M.F. (1973) Uterine infections in the camel. Egyptian J. Vet. Sci. 10, 17-22.

12. Nawito, M.F. (1967) Some reproductive aspects in the female camel. D.V.M. Thesis University of Agriculture, Warsaw, Poland. pp.109

13. Nur, H.M. (1984) Some reproductive aspects and breeding patterns of the Somali camel (Camelus dromedarius). In: Camel Pastoralism in Somalia. Ed. M.A. Hussein, Proceedings from Workshop in Baydhabo, Mogadishu, Somali Academy of Science and Arts, (Camel form Working paper, #7) 91-110.

14. Powers, B.E., Johnson, L.W., Linton, L.B., Garry, F. and Smith, J. (1990) Endometrial biopsy technique and uterine pathologic findings in llamas. J. Am. Vet. Med. Assoc. 197, 1157-1162.

15. Shawki, M.M., El-Hariri, M.N., Omar, M.A. (1985) Endometritis of she-Camel in Sharkeia Province. Egypt J. Vet. Sci. 22, 169-172.

16. Tibary, A. and Anouassi, A. (1996) Ultrasonographic changes of the reproductive-tract in the female camel (Camelus-Dromedarius) during the follicular cycle and pregnancy. J. Camel Practice and Res. 3, 71-90.

17. Tibary, A. and Anouassi, A. (1997) Breeding soundness examination of the female camelidae. In: Theriogenology in Camelidae: Anatomy, Physiology, BSE, Pathology and Artificial Breeding. Ed. A. Tibary. Actes Editions, Institut Agronomique et Veterinaire Hassan II. pp 243-310.

18. Tibary, A. and Anouassi, A. (1997) Reproductive physiology in the female camelidae In: Theriogenology in Camelidae: Anatomy, Physiology, BSE, Pathology and Artificial Breeding. Ed. A. Tibary. Actes Editions, Institut Agronomique et Veterinaire Hassan II. pp 317-368.

19. Tibary, A. and Anouassi, A. (1997) Reproductive disorders of the female camelidae In: Theriogenology in Camelidae: Anatomy, Physiology, BSE, Pathology and Artificial Breeding. Ed. A. Tibary. Actes Editions, Institut Agronomique et Veterinaire Hassan II. pp 317-368.

20. Tibar, A. and Anouassi, A. (1997) Management of reproduction in camelidae. In: Theriogenology in Camelidae: Anatomy, Physiology, BSE, Pathology and Artificial Breeding. Ed. A. Tibary. Actes Editions, Institut Agronomique et Veterinaire Hassan II. pp 459-476.

21. Tibary, A and Memon, M.A. (1999) Reproductive physiology in the female South American camelidae. J. Camel Practice and Res. 6, 217-233.

22. Tibary, A. and Anouassi, A. (2000) Reproductive disorders in the female camelid. In: Recent Advances in Camelid Reproduction. Eds. J.A. Skidmore and G.P. Adams. International Veterinary Information Service

23. Waldridge, B.M. and Pugh, D.G. (1997) Reproductive techniques in female lamoids. Vet. Med. 92, 651.

24. Wernery, J. (1991) The barren camel with endometritis - isolation of Trichomonas Fetus and different bacteria. J. Vet Med. B 38, 523-528.

25. Wernery, U. and Ali, A. (1989) Bacterial infertility in camels (Camelus dromedarius): Isolation of Campylobacter fetus. Dtsch. Tierärtzl. Wschr.;96:497-498.

26. Wernery, U. and Wernery, R. (1992) Uterine infections in the dromedary camel - a review. Proc. First Int. Camel Conf., Dubai, UAE. 155-158.

27. Wernery, U. and Kumar, B.N. (1994) Reproductive disorders in dromedary camels due to infectious causes and its treatment. J. Camel Practice and Res. 1, 85-87.

28. Zaki, K. and Mousa, A. (1965) The bacterial flora of the cervical canal, uterine horns and fallopian tubes in native cows and she-camels. Florpfl. Haust. Bd. 1, 229-232.