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Reproductive emergencies in camelids

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Abstract

Emergencies in theriogenology practice go beyond just saving the life of the patient, but also preserving its reproductive abilities. Camelid emergency medicine is a relatively new field. This paper discusses the most common reproductive emergencies, their diagnosis, treatment, and prognosis in male and female camelids. The conclusions drawn are based primarily on clinical observations by the authors over the last 25 years. Special consideration is given to peculiarities of the species, particularly in the choice of obstetrical manipulations and therapies.

Keywords: Camelid; Pregnancy; Infertility; Neonatology; Emergency

1. Introduction

In theriogenology practice, emergencies are defined not only in terms of concerns for the welfare of the patient, but also for its future reproductive life. The challenge often faced with reproductive emergencies is how to preserve the life of the patient and maximize the chance to maintain reproductive ability. In camelids, this is even more important, as assisted reproductive technologies have either not yet been perfected (semen preservation, in vitro embryo production, nuclear transfer) or are not allowed (embryo transfer) by some breed registries. In the case of pregnant females, which constitute the majority of reproductive emergencies, the life and welfare of the neonate must also be considered. The objective of the present paper is to review the most common reproductive emergencies in male, female, and neonatal camelids. This review draws primarily on the clinical experience of the authors, as there are very limited controlled studies regarding clinical reproduction and emergency care in camelids.

2. Reproductive emergencies in the male

Although many disease processes that present as emergencies may have some severe repercussions on the reproductive process in the male, our review will be limited to diseases and accidents with sudden onset that are directly linked to the urogenital system. Reproductive emergencies in the male camelid are primarily due to sudden onset of visible abnormalities in the external genitalia. These abnormalities can be summarized as acute scrotal or preputial swelling, preputial prolapse or paraphymosis, and post-surgical emergencies [1–3]. In camels, preputial swelling is also a primary clinical sign of acute trypanosomiasis, a disease with high morbidity and mortality in many countries where camel breeding is important [3].

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2.1. General approach to examination of the male for reproductive emergency

As with any other emergency, accurate body weight, body condition score, physical examination, degree of dehydration, baseline complete blood count (CBC), blood biochemistry, and urinalysis should be part of the initial evaluation. Immediate placement of an intravenous catheter is indicated in severely compromised or recumbent animals. Ultrasonography of the urogenital organs should also be conducted.

2.2. Acute scrotal swelling

Testicular thermoregulation is very important for normal spermatogenesis in camelids. Therefore, compromised testicular thermoregulation in these animals should considered serious, as the effect on spermatogenesis can be long lasting or permanent. Acute scrotal swelling is generally due to heat stress, trauma, or a local or systemic infectious process. Testicular torsion and scrotal hernia are commonly considered as differential diagnoses in other large animal species, but have never been encountered in camelids in our practice [2].

2.3. Heat stress

Scrotal and preputial edema and development of severe hydrocele are features of heat stress in the male llama and alpaca [2]. This syndrome is relatively common in the USA. Factors predisposing to heat stress include prolonged high ambient temperature and humidity, inadequate shade, long fleece, dark coat color, and obesity. The risk for heat stress is exacerbated by stresses such as transportation, exercise, fighting, and breeding [4,5]. Hyperthermia results from impaired evaporative cooling, particularly under hot and humid conditions [5]. Scrotal edema may be the first clinical sign in the male. The exact pathophysiology of the scrotal and ventral abdominal edema is not well understood. Contributing factors may include inability of the pampiniform plexus and testicular artery to cope with the fluid turnover, or vascular thermal injury resulting in impaired wall permeability and extravasation of intravascular proteins, electrolytes, and fluid into the interstitium.

Many cases may resolve spontaneously, but leave the male infertile for various intervals, usually lasting from 2 months to years [2]. Spermatogenesis (sperm production and semen quality) was severely impaired in llamas housed at an ambient temperature of 29 °C for 4 weeks [6]. These temperatures, relatively common in summer months in many countries outside the native range of South American camelids, can result in infertility due to decreased sperm numbers, decreased motility, and increased abnormalities. The heat index (ambient temperature × humidity) would cause even more severe changes in hot and humid summers [6].

In advanced cases, other clinical signs appear and include hyperthermia, increased salivation, anorexia, depression, ataxia, muscular weakness, dehydration, ketosis/hepatic lipidosis, and dyspnea/hyperpnea [4,5]. These animals generally display an inflammatory or stress leukogram. Anemia may be secondary to hemolysis. Serum biochemical abnormalities may include hypophosphatemia, hypocalcaemia, hypomagnesaemia, hyponatremia, hypochloridemia, hypo- or hyperkalemia, hyperglycemia, and elevated serum AST and CPK concentrations. Serum glucose concentration >300 mg/dL has been associated with a poor prognosis. Severe electrolyte imbalances and damage to the thermoregulatory center in the hypothalamus will be the end point of the disease progress in nontreated animals, leading to multi-organ damage or failure and increased mortality [4,5].

Stabilization of the heat-stressed animal should include urgent cooling of the core body temperature to the normal range (shearing, spraying the ventral abdomen with cold water, fan), and fluid therapy to rehydrate the animal and correct metabolic abnormalities. Intravenous isotonic sodium bicarbonate solution may be required to treat metabolic acidosis. Maintenance fluid rates are 30–40 and 80–120 mL/kg/day in adults and crias, respectively. Pulmonary edema is a serious risk if fluids are administered too fast (>20 mL/kg/h). Palliative therapies against other complications should include nasal oxygen insufflation in hypoxemic patients, nonsteroidal anti-inflammatory drugs (NSAIDs; e.g. flunixin meglumine), antioxidants (vitamin E and selenium), and broad-spectrum antibiotics. Steroids such as dexamethasone may be indicated in advanced cases, but should not be used in females in the second half of pregnancy. Therapeutic diuresis with furosemide is indicated in animals with respiratory distress due to pulmonary edema.

Heat stress is best prevented by timely shearing, adequate hydration (clean, cool water) and providing shade and cooling mechanisms such as sprinklers, a pond, or wading pool. Prevention of obesity and reduction of stresses of long transportation, handling and breeding during the hottest part of the day also reduce the risk for heat stress. The primary indicator of heat stress risk is not only the ambient temperature, but

also the humidity. The heat stress index (HSI), expressed as the ambient temperature (°F) + humidity (%), is considered too high when it reaches or surpasses 160 (e.g. combination of 100 °F and 60% humidity).

2.4. Trauma

Traumatic injuries to the scrotal area are relatively common in the male camelid and are usually inflicted by other males; they occur when new, mature males are added to a paddock, particularly when competing for breeding. Severe traumatic fighting injuries are more common in camels during the rutting season [7,8]. Scrotal traumatic injuries are relatively rare in wild camelids, probably because of their strict social organization.

Traumatic injuries are often due to bites and can range from a superficial scrotal laceration to severe testicular rupture and hemorrhage. Testicular hemorrhage may occur without external lacerations, but requires ultrasonographic evaluation of scrotal contents [7]. Treatment protocols should focus on reducing local swelling, preventing infectious complications, and providing a tetanus toxoid booster. Unilateral castration is the treatment method of choice for severe unilateral testicular trauma involving the tunica vaginalis and testis [8].

2.5. Orchitis

Testicular and epididymal inflammation may present as an emergency in the male camelid. The most common complaint is a sudden onset of lameness or reluctance to breed and visible swelling of the scrotum. Various infectious agents have been reported in cases of orchitis that are spread by hematogenous routes, such as *Brucella abortus*, *Brucella meletensis* and *Streptococcus equi zooepidemicus*, or the agent may ascend from scrotal wounds [9,10]. Treatment with systemic antimicrobials is often unrewarding. Therefore, for unilateral orchitis, unilateral orchidectomy is the best option for the welfare of the male and salvage of reproductive ability [8,9].

2.6. Acute penile/preputial swelling

Acute penile or preputial swelling may be due to complications from urolithiasis or traumatic injuries. The etiology of urinary calculi in the camelid is not well understood, but is suggested to be similar to that in other domestic ruminants [11–17]. Early clinical signs of urethral obstruction often go undetected. Some males may show increased straining to defecate, odontoprisis, inappetence and ileus, followed by anorexia, frequent unsuccessful attempts at micturition or dribbling blood tinged urine, and signs of abdominal discomfort [13–16].

Complications of urethral obstruction include urethral or urinary bladder rupture. This may happen within 2 days of the first clinical signs. In emergency cases, the animal presents with anorexia, inability to pass urine, and signs of depression. Physical examination often reveals tachycardia, tachypnea, and elevated rectal temperature. Complete blood count may reveal an elevated white cell count and neutrophilia with a left shift, increases in fibrinogen, increased creatinine kinase and aspartate aminotransferase activity, hyperglycemia, hypercreatininemia and increased urea nitrogen. Serum electrolyte abnormalities included hyponatraemia, hypochloraemia, and hyperkalaemia. Fluid obtained by abdominocentesis or from the preputial swelling has increased creatinine concentration [12–16].

Increased serum urea nitrogen and creatinine concentrations suggest uroperitoneum [16]. Transcutaneous ultrasonography of the ventral abdomen may enable visualization of subcutaneous free fluid and tissue edema in the case of urethral rupture and a large volume of free fluid in the abdominal cavity in the case of urinary bladder rupture. With the latter, it may not be possible to visualize the urinary bladder. Transrectal ultrasonography may reveal dilation of the pelvic urethra if the bladder is intact. The prognosis is grave if there is hydroureter and hydronephrosis [16].

Uroliths are often located in the distal penile urethra, approximately 7–12 cm from the penile orifice, but are occasionally immediately proximal to the sigmoid flexure. Camelids, like domestic ruminants, have a urethral recess at the ischial arch, making catheterization of the urinary bladder exceedingly difficult. Management techniques for obstructive urolithiais is similar to those reported in ruminants and include repair of the ruptured urinary bladder and relief of the obstruction via retrograde flushing and urethrotomy. However, these techniques do not salvage the reproductive career of the animal. Flushing, followed by tube cystotomy, may be the only option to try to salvage the reproductive life of the animal [16].

Postsurgical management should include multiple therapies, including antimicrobial (procaine penicillin, 30,000 IU/kg IM, twice daily; and gentamicin sulphate, 6.6 mg/kg IV, once daily), anti-inflammatory (flunixin meglumine, 1 mg/kg IV, twice daily) and intravenous fluids. Prognosis for life is fair, but prognosis for return to breeding is usually guarded [16].

2.7. Preputial/penile trauma

Preputial lacerations are relatively common in breeding males. They are usually a consequence of masturbation (breeding the ground or objects) or complications from foreign objects within the prepuce. Hair-ring lacerations of the penis are common in llamas and Suri alpacas. Males may present because the owner has observed an abnormal protrusion of the prepuce, or discomfort during urination or mating. However, bloody or purulent discharge may be the only clinical sign. Preputial and penile lacerations can quickly become complicated and jeopardize the reproductive life of the male due to development of severe inflammation and adhesions. Injured males may continue to attempt breeding, further exacerbating the lesions [7].

Evaluation of penile and preputial injuries is best performed under heavy sedation or general anesthesia. The penis should be completely exteriorized and inspected for lesions. 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. The initial treatment is to replace viable prolapsed preputial mucosa and maintain it in place with a purse string suture. Daily cleaning of the sheath with saline, and application of local anti-inflammatory and antimicrobial ointment (petercillin) 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. Prognosis for return to normal breeding activity is poor if adhesions or abscesses develop at the base of the prepuce [2,18].

2.8. Post-surgical emergencies

The most common post-surgical complication in the male camelid is post-castration hemorrhage, often secondary to inadequate time to insure hemostasis of the testicular cord. Management of these conditions is not different from other species and includes placing the male in a calm environment and packing the bursa for 6–24 h. Several commercial hemostatic agents are available and may be helpful [19].

3. Specific conditions in camels

3.1. Soft palate prolapse

Exteriorization of the soft palate (Dulla) is a characteristic rutting behavior in the dromedary camel [7]. Furthermore, permanent exteriorization of the soft palate during the rut season is a common in the dromedary. This usually starts with an impaction of the diverticulum with food or a foreign body [20,21]. Part of the impacted soft palate becomes trapped under the molars and is traumatized during mastication. Traumatic lesions of the soft palate range in severity from superficial cuts and bruises to severe lacerations accompanied by hemorrhage; these lesions are rapidly complicated by infection and development of severe inflammation and edema. Formation of large abscesses is not uncommon. In most cases, the inflamed organ is permanently hanging from the side of the mouth and becomes progressively necrotic [22–24]. In a few cases, the soft palate is swollen, but not exteriorized, and blocks air exchange, which may lead to asphyxiation. If the condition is not treated, the animals become emaciated due to dysphagia and impairment of mastication and deglutition. Management of these cases requires surgical ablation of the soft palate [20]. Surgical excision of the soft palate can be performed under heavy sedation and a local block. Large vessels are ligated with resorbable suture material. Laser ablation is the best approach. Post-surgical management includes administration of NSAIDs, antimicrobials, and tetanus prophylaxis. Animals should be on soft feed for at least 3–4 days after surgery.

3.2. Rupture of the urethra

Urethral rupture and subcutaneous infiltration of urine is relatively common in draught camels and is due to a tight strap. Advanced stages are managed surgically by complete urethrostomy. Animals present with varying degrees of ventral swelling and prolapse of mucocutaneous junction of the penis and prepuce. Tissue necrosis is common, and may include the penis due to pressure ischemia. Surgical debridement [25], phalectomy, or both, may be required [26].

4. Reproductive emergencies in the female

Reproductive emergencies in female camelidae can be divided into emergencies occurring in the nonpregnant female, severe pregnancy complications, obstetrical emergencies, and postpartum emergencies. Emergencies requiring intervention during parturition and the immediate postpartum phase must concurrently take into account emergencies pertaining to the neonate.

4.1. Emergencies in the nonpregnant female

The most common reproductive emergencies in nonpregnant females are traumatic injuries during breeding or iatrogenic injuries during reproductive examinations. Although rare, breeding trauma may occur during an unsupervised paddock mating. In camels, traumatic injuries are not always restricted to the reproductive tract, and include bite wounds and fractures of the pelvis and/or dislocations. These traumatic injuries are seen in multiple-sire breeding systems. In South American camelids, breeding trauma may occur by heavy llama males trying to breed alpacas. Discussion of these types of traumatic injuries are beyond the scope of this paper, but should be considered in downer syndrome in females with a history of recent (<24 h) mating.

Iatrogenic traumatic injuries are by far the most common emergency in camelid practice; they include perforation of the rectum, colon, vagina, or uterus. Anal sphincter bleeding due to excessive stretching and rectal prolapse can occur secondary to transrectal palpation, particularly when there is already a predisposing factor for excessive straining (e.g. pelvic mass, urinary bladder disease). However, these are not life threatening and can be managed successfully with sedation, a caudal epidural, and protection of the prolapsed tissue.

4.2. Rectal/colonic perforation

Rectal and colonic injuries have been reported in llamas and alpacas, and are a common reason for malpractice suits. Rectal or colonic injuries may happen during breeding, but they more commonly are due to excessive manipulation during transrectal palpation or ultrasonography [27,28].

The examiner will usually recognize that an injury has occurred when palpating llamas and camels. However, in alpacas, when the ultrasound transducer is mounted on an extension for reproductive examination, the practitioner may not detect evidence of perforation until it is too late. The amount of blood retrieved with the palpating hand is variable; it is the sensation of rupture or tear that is most indicative of the seriousness of the injury. Since the distance between the anus and the peritoneal reflection is very short (2–3 cm in alpacas, 4 cm in llamas, and 6–10 cm in camel), complete rectal tears in camelids are rapidly complicated by peritonitis. Often the only clinical sign is reluctance to stand, lethargy and progressive dehydration a few hours after a reproductive examination. Severe toxic shock and death follows within 8–24 h if no medical action is taken.

All suspected rectal or colonic injuries should be immediately referred to a surgical facility. The animal should be sedated and started on intravenous antimicrobial and anti-inflammatory therapy for transport. Further evaluation at the referral facility includes CBC, blood chemistry, transabdominal ultrasonography, and abdominocentesis. Animals with evidence of peritonitis should be immediately prepared for surgical correction by celiotomy or celiotomy and pubic symphysiotomy to allow peritoneal lavage. Stable patients without alarming changes in their blood and peritoneal fluid characteristics may be further evaluated under epidural anesthesia to decide if a transanal repair is possible. Evaluation of the injury can be performed under general anesthesia. The anal sphincter is dilated using stay sutures on the mucocutaneous junction. Gentle evacuation of the rectal cavity may be attempted by low-power vacuum aspiration until the lesions can be visualized. Use of a flexible videoendoscope can facilitate this evaluation. In llamas and camels, lacerations due to transrectal palpation are usually located in the ventral aspect of the rectum, 5–20 cm anterior to the anus. However, in alpacas, particularly when the perforation has occurred with a transducer mounted on an extension, the lesion can be dorsal. Also, in these cases, the presence of more than one perforation is possible, perhaps due to faulty alignment between the extremity of the transducer and the extension rod. Transanal repair is successful if the laceration is not deep [28]. Celiotomy with pubic symphysiotomy is the only option for caudal injuries and in particular for alpacas. Successful repair of rectal and colonic injuries by celiotomy or celiotomy/pubic symphysiotomy has been reported in a few llamas [28].

Preventive measures for colonic rectal injuries include use of caution when choosing the candidate for transrectal palpation, ample lubrication, and cautious use of an extension rod, particularly in maiden or agitated females. Sedation of the female or relaxation of the rectum and rectal sphincter may be obtained by epidural anesthesia or instillation of 2% lidocaine into the rectal cavity before examination.

4.3. Uterine and vaginal perforation

Most cases of uterine perforations seen in our practice are iatrogenic, due to aggressive placement of Foley catheters, infusion pipettes, and biopsy forceps. These are more common in alpacas than in llamas and camels. They become an emergency if a major blood vessel is

damaged, or if an irritating substance (e.g. iodine) is infused into the abdominal cavity. Females with these injuries may present with colicky signs consistent with peritonitis or hemoperitoneum. Anemia is a feature if there is sufficient blood loss; for example, one animal had a PCV of 10% following an endometrial biopsy. Suspicion is based on a history of recent gynecological examination and the feel of a ''pop'' during manipulation. The patient should be worked up as for any case of colic of abdominal origin [12]. Supportive therapy includes NSAID's and antimicrobials. Blood transfusion and surgical intervention may be indicated if the PCV is <8%. Vaginal perforation with severe bleeding may be controlled by vaginal compression packs.

4.4. Emergencies in the pregnant female

Any clinical syndrome occurring during pregnancy may have a serious effect on the fetus. Therefore, monitoring fetal well-being should be part of any protocol for medical management of the pregnant female and particularly in the case of emergencies. Camelids rely exclusively on the CL for progesterone secretion and maintenance of pregnancy. Therefore, severe illness associated with an inflammatory or extreme stress response may rapidly lead to luteolysis and abortion (with all its complications).

Pregnant females may present with a variety of emergency clinical syndromes, ranging from severe colic, downer (lateral or sternal continuous recumbency), anorexia, diarrhea, depression, neurologic conditions, excessive straining, vaginal discharge, premature lactation, vulvar dilation, or vaginal prolapse. Some of these presentations may have a genital origin. The cardinal rules in handling emergencies in the pregnant females are a thorough physical evaluation of the dam, evaluation of the fetus, and ruling in or out the genital origin of the presenting complaint after stabilization of the dam. The main emergencies of genital origin in the pregnant female are uterine torsion, vaginal prolapse, impending abortion, and uterine rupture. The main complication of any emergency in late pregnant females is hepatic lipidosis. Pregnancy can also exacerbate clinical diseases. For example, in a recent outbreak of respiratory diseases in alpacas and llamas in North America, morbidity and mortality was highest in females in their last trimester of pregnancy.

4.5. Clinical evaluation of the pregnant female

An important principle in our practice is that any suspicion by an owner that ''something is wrong'' with a pregnant female is taken seriously. Behavioral assessment may be conducted while taking history, unless the female is obviously depressed or painful. A detailed history should be obtained and include breeding dates, time and methods used for pregnancy diagnosis, history of previous illness of reproductive disorders, onset and duration of the clinical problem, and recent treatments. If the female is obviously in severe distress, blood samples should be taken immediately and the female stabilized before further examination. Oxygen therapy may be indicated for severely compromised females. A jugular catheter should be placed immediately to allow fluid therapy and emergency anesthesia if needed.

Sedation may be needed for some females in order to complete evaluation. Choices of drugs and dosage for sedation should take into account their effect on the fetus. Butorphanol tartrate (0.05–0.1 mg/kg) provides good sedation and has minimal effect on the cardiovascular system. However, there is a mild decrease in systemic vascular resistance that can be relevant if uterine blood flow is already compromised [29].

Transabdominal ultrasonography should be used to determine fetal well-being, and the integrity of the uterus and placenta. In addition to the reproductive organs, abdominal viscera and the peritoneal cavity should be assessed [30]. In advanced pregnancy, imaging of abdominal viscera becomes very difficult in the absence of severe displacement. For complete imaging of abdominal contents, the lower abdomen should be clipped and cleaned with alcohol from the xyphoid region to the base of the mammary gland. The area to be examined may need to be extended dorsally to the flank in order to visualize the dorsal aspect of the abdomen and the kidneys. Cranially, the projection area of the liver may also need to be prepared for examination. For transabdominal ultrasonography, a 5 MHz linear-array transducer may be sufficient for mid-pregnancy and in small patients, whereas in the last trimester, the use of a 2.5–3.5 MHz sector transducer provides better penetration and imaging of the abdomen. Transabdomimal ultrasonography may also be used to locate distinct pockets of free peritoneal fluid and to perform abdominocentesis.

Other imaging techniques such as radiography, MRI or CT scanning may be indicated in the case of downer females, but they are not routine procedures and are only a possibility in referral centers. Following transabdominal ultrasonography, transrectal palpation and ultrasonography should be performed, albeit, cautiously, as this may cause additional stress. Administration of an epidural and infusion of a mixture

of lidocaine and lubricant in the rectal cavity may reduce straining, provide some relaxation, and facilitate the examination in llamas and alpacas. The primary objective of transrectal palpation is to determine the location and direction of the broad ligaments and evaluate the caudal abdomen for any masses or abnormalities of the pelvic area, kidneys, and urinary bladder. Transrectal palpation in the female sitting in a sternal position may offer some challenges for the inexperienced practitioner. The quantity and quality of fecal material in the rectal cavity should be evaluated. Severely stressed camelids often have profuse diarrhea, whereas an absence of fecal material and/or the presence of scant mucoid feces may be due to intestinal transit disorders or tenesmus.

Vaginal examination should be performed with a speculum after thoroughly cleaning the perineal area. The speculum should be advanced slowly, while concurrently examining the vagina for any abnormalities. The cervix is evaluated for the degree of relaxation and opening. The cervix of the llama and alpaca is often difficult to visualize during late pregnancy, but it should be obvious if it is patent. Manual examination of the vagina and cervix may be indicated in some cases, but this procedure is often limited by the size of the examiner's hands.

4.6. Fetal and utero-placental evaluation

Assessment of fetal well-being is an important component in the evaluation of medical crises. Unfortunately, there is a paucity of information regarding fetal biophysical characteristics in camelids. However, based on clinical experience in the authors' laboratory, the two main indicators for fetal distress are fetal heart rate and rhythm. Normal fetal heart rate in mid- to late-pregnancy range from 1.6 to 1.8 times that of the dam. In that regard, fetal heart rate is usually 80–115 bpm in the last trimester of pregnancy, but decreases to 80 bpm a few days before parturition. Fetal heart rates that are consistently >130 or <50 bpm suggest fetal distress. The fetal heart rhythm should be regular and respond to phase of activity by a 10–20% increase in rate. Fetal activity is maximal in the first half of pregnancy, but substantially reduced in the last 2 months. The entire fetus should be examined to determine fetal position and number. Normal fetal positioning for parturition appears to occur a few hours before parturition. It is not uncommon to image the fetus low in the abdomen with the dorsum against the diaphragm and all limbs pointing to the pelvic area. Transverse position of the fetus in the abdomen does not mean a transverse position inside the horn, but rather reflects the position of the entire pregnant horn. That the fetus is entirely in the left horn and the special arrangement of the pregnant horn vis-à-vis the abdominal viscera may contribute to signs of discomfort in some females in late pregnancy. Late in pregnancy, the presence of twins is best confirmed by abdominal radiography [31].

Fetal biometrics may provide data regarding fetal growth and stage of pregnancy, but in our experience, most measurements are not very accurate and cannot be used for physical bioprofiling [32,33]. Fetal fluids are difficult to assess, due to the low volume of amniotic and allantoic fluid in camelids.

Uteroplacental thickness should be evaluated in the horn containing the fetus (left horn) only, as the placenta may appear thicker in the nonpregnant horn. The combined uteroplacental thickness should be <8 mm in the last trimester. Excessive edema of the uterine horn or premature placental detachment are relatively easy to detect and require immediate intervention if the female is at term.

4.7. Ancillary laboratory testing

A minimum baseline evaluation of a severely depressed or colicky pregnant female should include complete blood count (CBC), blood chemistry, and fibrinogen. Evaluation of peritoneal fluid (abdominocentesis), fecal evaluation, and urinalysis should be considered in select cases. Although a stress leukogram is often present in many females, neutrophil count, immature neutrophil count, neutrophil morphology, packed cell volume, and fibrinogen concentration are very valuable in evaluating inflammatory and toxic states. Anemia may be due to blood loss, or the onset of other problems such as *Mycoplasma hemolamae*. Blood chemistry will determine electrolyte imbalances and risk for hepatic lipidosis, a major concern in anorectic, stressed pregnant females. Hypoprotenemia is often present in old pregnant females and may predispose to metabolic complications. In some cases, the serum may be grossly hyperlipemic (white). However, lipemia and ketonemia are not always present in hepatic lipidosis. Elevated concentrations of nonesterified fatty acid (NEFA; >400 μmol/L) and β-hydroxybutyrate (BHB) are important indicators of stress and liver compromise. Liver compromise is also indicated by elevated bile acids, gamma-glutamyl transferase, aspartate transaminase, and sorbitol dehydrogenase [17,34]. Furthermore, arginal calcium and magnesium concentrations or

hypocalcemia may be present in late-pregnant females and require correction and monitoring.

4.8. Endocrine evaluation of the dam

Progesterone is the major hormone evaluated routinely during pregnancy [35,36]. Determining baseline progesterone concentration is a good practice if an assay is readily available. The CL is the primary source of progesterone throughout pregnancy in camelids; pregnancy cannot be maintained if blood progesterone concentrations are <1 ng/mL [37]. Progesterone concentrations may be substantially altered by level of hydration and weight and body condition score of the female. Progesterone supplementation is still a subject of debate. Estrone sulfate concentrations in plasma increase after 80 days of pregnancy, reaching a peak immediately before parturition.

Determination of relaxin concentration may be helpful in the evaluation of placental function, but this assay is not widely used [35]. There are no studies on the effect of a compromised liver (typically due to hepatic lipidosis) on steroid metabolism and blood steroid concentrations.

4.9. Supportive therapy of the compromised pregnant female

Supportive therapy in pregnant females depends on the symptoms and degree of compromise. It may include oxygen therapy, fluid therapy, antimicrobials, and NSAID's. Compromised pregnant females should be placed immediately on broad spectrum systemic antimicrobials. Our primary choices of antimicrobials have been ceftiofur in alpacas and llamas and long-acting tetracycline in camels.

4.10. Uterine torsion

Uterine torsion remains the main genital cause of colic or depression in pregnant New World camelids. There are no detailed studies regarding the epidemiology of this disorder. It is noteworthy that uterine torsion is not common in camels (A. Tibary, unpublished observations), nor is it common in llamas and alpacas in South America (J. Sumar, personal communication). Perhaps this apparent difference is due to nutrition or body size.

In our experience, there are two common stages of pregnancy at presentation: 8–10 months and at parturition. Clinical signs of uterine torsion are quite variable, ranging from mild discomfort to severe colic, diarrhea, and anorexia. We have had cases present simply as ''quieter than usual'' and ''decreased appetite'' or ''just a little off her normal routine'' [31].

The female may display signs of pain, circling, kicking at the belly, lateral recumbency, and excessive vocalization. Tachypnea and tachycardia are very common. The CBC and blood chemistry are consistent with a stress leukogram, with various metabolic changes (hepatic lipidosis) depending on the duration and severity of the problem [38].

Diagnosis is based on transrectal palpation of the broad ligaments, as described in other large animal species [31,38]. Clockwise torsion is indicated if the left broad ligament is stretched across midline to the right and over the uterus, whereas the right ligament is shorter and pulled ventrally and medially under the uterus. Palpation of the broad ligament may elicit a severe painful reaction. Difficulties encountered in transrectal evaluation for uterine torsion include physical limitations, particularly in alpacas (tight anal sphincter, narrow pelvis and size of the examiner's hand and arm), as well as a lack of experience palpating late-pregnant camelids in a sternal position. Although diagnosis by vaginal palpation has been reported by practitioners, in our experience, it is not reliable unless the torsion includes the cervix. With a severe colic, a definitive diagnosis may not be possible until exploratory laparotomy. Alternatively, the female could be palpated under general anesthesia, which provides greater relaxation of the anal sphincter and perineal area [39]. Transrectal ultrasonography may sometimes reveal increased dilation of the blood vessels. Although it was reported that the majority ($>90\%$) of camelid uterine torsions are clockwise [38], this has not been our experience; therefore, direction of the torsion needs to be ascertained before attempting nonsurgical correction.

Correction of uterine torsion can be accomplished nonsurgically by rolling or surgically after coeliotomy. Both techniques are very efficient. Rolling should be considered only if the uterus and its vasculature are not compromised. Rolling may be performed done under general anesthesia, sedation, or without sedation. The female is placed on lateral recumbency on the side of the direction of the torsion and rolled while the fetus is maintained in position with a small plank or with the fists [31,38]. The pain usually disappears immediately after correction of the torsion and females may return to normal activity immediately. However, if they have been anorexic, correction of metabolic disorders should included in post-surgical management. Surgical correction may be performed following flank or midline

laparotomy. Midline laparotomy is the preferred method in late pregnancy [39–42]. The success rate of both rolling and surgical correction is very high, as is survival of the fetus. No special management is needed if the torsion has been diagnosed and corrected early. However, anorexia and pain may cause hepatic lipidosis, in which case the patient should be placed on broad spectrum antimicrobial therapy [39]. Monitoring blood progesterone is useful, particularly if an assay is readily available. The need for progesterone supplementation after correction of a torsion remains controversial.

Complications of uterine torsion include abortion, uterine rupture/hemorrhage, endotoxemia, and death of the dam [38,40]. Splenic torsion concurrent with uterine torsion has been described in one case, with persistent pain following correction of the uterine torsion [39].

4.11. Uterine rupture

Uterine rupture is often secondary to severe or inadequate clinical management of a uterine torsion. Females usually present in an advanced stage of shock, in lateral recumbency. Abdominocentesis may reveal large amount of serosanguinous or bloody fluid. Severe pain with presence of serosanguinous peritoneal fluid may also be due to splenic torsion [39]. The only option is surgical intervention to remove the fetus and salvage the uterus. Complete hysterectomy should be considered if the uterus is severely compromised.

4.12. Vaginal prolapse

Vaginal prolapse has been described during the first half of pregnancy, but the condition is more common during the last 2 months of pregnancy [31,43–45]. It is likely due to softening of tissues due to increased estrogen concentration during the last part of pregnancy. Predisposing factors include age (older females), parity, and body condition (obese and very thin females) [31,45].

The prolapse tissue may be limited to 3–5 cm, and visible only in the recumbent female. However, with increased inflammation and edema of the tissues, the degree of prolapse increases and becomes permanently exteriorized. Prolapse of the entire vagina and exteriorisation of the cervix is rare, but possible. Prolonged periods of prolapse increase inflammation and can cause severe necrosis of the vaginal mucosa, potentially resulting in ascending infectious placentitis. Increased tenesmus with risk of abortion and/or rectal prolapse occurs in chronic cases. Furthermore, rectal and vaginal prolapse may be the only indications of dystocia or abortion [45].

The prognosis for the life of the fetus and dam is relatively good if the condition is treated early. In camels, the vaginal tissue is maintained in place with a Bühner suture around the vulva. In the alpaca and llama, a shoelace suture pattern is sufficient. More advanced cases of prolapsed vagina with increased tenesmus may require epidural anesthesia [44]. The animal should be monitored regularly and the suture removed if signs of impending parturition are observed [41].

4.13. Other complications of pregnancy

Other complications of pregnancy in camelids include ventral abdomen herniation, prepartum downer syndrome, metabolic diseases, and premature lactation/placentitis. Hydrops of fetal fluid is extremely rare in camelids. Ventral herniation during pregnancy is often a complication of previous abdominal surgeries, including cesarean section. In addition to determining the primary cause of these disorders and assessing the chances for survival of the female, determination of fetal well-being and the possibility of induction of abortion or parturition should be contemplated. Abortion can be induced with the prostaglandin $F_{2\alpha}$ analogue, cloprostenol (250 μg in llamas and alpacas, and 500 μg in camels). The same dose is sufficient for induction of parturition, with good neonatal survival at >330 days of pregnancy and sufficient mammary gland development and colostrum production. Abortion or parturition occurs approximately 18–22 h after prostaglandin treatment. In a few situations, a second treatment with a prostaglandin $F_{2\alpha}$ analogue is necessary [45–47]. Giving llamas or alpacas >5 mg of $PGF_{2\alpha}$ (dinoprost thrometamine) has been associated with severe respiratory distress.

4.14. Obstetrical emergencies

Most neonatal deaths occur during birth or shortly thereafter. Adequate obstetrical management and monitoring for early signs of distress are closely linked with the chances of survival of the cria and the reproductive future of the dam. Proper procedures, immediate neonatal care, and close of observation of the newborn, are the best means of reducing neonatal losses.

Normal parturition and proper obstetrical techniques have been reviewed in detail elsewhere and are not very different from the approach used in other large animal species (especially horses) [31]. It is estimated that

approximately 5% of all camelid births will require some assistance and ∼2% will require advanced obstetrical expertise. Obstetrical problems are an emergency in camelids, due to the relatively explosive and short duration of stages of parturition (similar to the mare). All normal births are in an anterior longitudinal presentation.

Dystocia of maternal origin include uterine inertia, uterine rupture, and failure of appropriate dilation of the cervix or vestibulum [31,45,48]. Uterine torsion and failure of cervical dilation require delivery by cesarean section. However, it is important to confirm that the dam is at term and to first rule-out uterine torsion [31,49].

Dystocia of fetal origin occur most commonly as a result of malpositioning or malposture, and to a lesser degree, presence of malformations, twins, and large fetuses. The most common fetal causes of dystocia are carpal or shoulder flexure or head deviations (lateral and ventral). Breech and transverse presentations are possible and are common reasons for cesarean section [31,50].

Fetal abnormalities causing dystocia include *Schistosoma reflexus*, contracted tendons, and ankylosis of the hind limbs or neck [7]. Other anomalies that may complicate delivery include fetal anasarca and an emphysematous fetus resulting from fetal death and gas production during decomposition [31].

Although twining is rare in camelids, a few twin births have been reported. Delivery of twins may be complicated by both fetuses in the birth canal at the same time. In our experience, all dystocias due to twins required a cesarean section to preserve the integrity of the female reproductive tract [31].

4.15. General considerations for obstetrical manipulations

Regarding obstetrical procedures, there are three major differences between camelids and ruminants: (1) the pelvic inlet is narrower; (2) the cervix and vaginal are more prone to laceration and severe inflammation (often leading to adhesions); (3) risks for neonatal hypoxia and death are increased by the forceful uterine and abdominal contractions and the rapid detachment of the microcotyledonary placenta. Consequently, (1) early recognition of dystocia is paramount, (2) obstetrical decisions and manipulations should be rapid, and (3) supportive care should be provided to the dam and fetus (if alive) before and during manipulation.

Dystocia is recognized by prolongation of the first or second stage of labor. Assessment of the health of the female and viability of the fetus is the first step in managing obstetrical cases. Providing analgesia (epidural and administration of butorphanol) may facilitate examination of the parturient alpaca. Prolongation of the first stage of parturition is primarily due to failure of cervical relaxation and uterine torsion [50].

Examination of the parturient female is continued by vaginal palpation to judge cervical dilation, determine the presentation, posture and position of the fetus and its viability, and to formulate a course of action based on the findings. Abdominal radiography may be helpful in determining position, posture and number of fetuses in alpacas [31,50].

Fetal manipulations are similar to other species, but need to be restricted to a maximum of 15–20 min. A different approach should be attempted if fetal position, presentation, and posture suggest that manipulation is not possible, or if manipulations are not fruitful after 15 min. We consider that fetotomy is not an option in alpacas and most llamas and camels. Surgical relief of dystocia (cesarean section) remains the best approach if controlled vaginal delivery cannot be achieved in <20 min. Techniques for cesarean delivery in camelids are well described [41,51]. We recommend a flank approach in camels and any severely compromised dam. This technique does not require deep general anesthesia and can be performed under sedation and a regional block, which is a good choice under field conditions. A midline celiotomy approach is ideal if the uterus is compromised or needs to be completely exteriorized [41,51].

Regardless of the type of obstetrical intervention, adequate oxygen delivery to the uterus is essential for a healthy neonate. Reducing uterine blood flow or oxygen-carrying capacity of the blood is liable to harm the fetus and may increase fetal or neonatal mortality. In most species, uterine blood flow is reduced when the dam is exposed to pain or stressful conditions. Sedatives, analgesics, and anesthetics may all supress cardiac output and therefore decrease blood flow to the fetus. In addition, certain drugs or drug combinations may further decrease uteroplacental perfusion, due to their tonic effect on the myometrium. Unfortunately, there are no studies on the effects of anesthetics on the uterus and fetus in camelid.

Xylazine, a drug of choice for sedation of camelids in the field, markedly reduced blood flow (by as much as 59%) and availability of oxygen to the uterus. Furthermore, 5 min after xylazine treatment, uterine artery resistance increased by 165%. Xylazine has also been associated with increased myometrial contraction in ruminants and could cause increase fetal morbidity and

mortality, at least in these species [52,53]. This effect was not significant in mares. There are no studies on the effect of xylazine on uterine perfusion in camelids.

In sheep, the fetus responds to hypoxia, hypotension and hypovolumia with increased concentrations of ACTH, vasopressin and cortisol, via activation of the hypothalamic–pituitary axis, mediated by changes in afferent neural activity of arterial baroreceptors and chemoreceptors; it has been suggested that the fetal response is primarily mediated through chemoreceptors [54]. Ketamine, a dissociative anesthetic and known noncompetitive inhibitor of glutamatergic *N*-methyl-D-aspartate (NMDA) receptors, blocks the fetal reflex bradycardic response to maternal ventilatory hypoxia and may not be a good choice for anesthesia. This corroborates our observations in camelids where use of ketamine as a preanesthesic has been associated with severely depressed neonates.

Propofol (2,6-di-isopylphenol compound) is a small molecule that is rapidly metabolized; its advantages are rapid onset and offset of action and redistribution from the central nervous system. Even with continuous propofol anesthesia, maternal and fetal heart rate and blood pressure were not affected in pregnant ewes [55]. This makes the drug ideal for induction of anesthesia for cesarean section or for surgical management of uterine torsion. Propofol decreased myometrial activity in the gravid ovine uterus *in vivo* [56] and in uterine muscle from gravid humans *in vitro* [57]. *In vivo*, there is no effect on placental perfusion. It can induce a transient tachycardia and decrease in PO2 and pH in the dam, but these effects have minimal repercussions on fetal heart rate and blood pressure. Because propofol is primarily metabolized by the liver, it should be used with caution in females with hepatic lipidosis. Maintenance of general anesthesia with isoflurane or sevoflurane are ideal, because these inhalation anesthetics are rapidly eliminated [56]. The combination propofol/isoflurane has been used successfully by our group in emergency cesarean section in camelids; a similar combination was also very good for cesarean section in the bitch [60,61]. It is noteworthy that the effects of these anesthetics may be exacerbated by pre-existing conditions in the fetus (e.g. hypoxia) [56,58,59].

4.16. Postpartum emergencies

Postpartum emergencies are often due to complications of obstetrical situations. However, females may present for emergency critical care with a history of what appears to have been an uncomplicated parturition. In addition to the primary genital problems that may alarm the owner (i.e. traumatic injuries, bleeding, uterine prolapse, and retained placenta) some of these cases present with ataxia, prolonged recumbency, and varying degrees of anorexia or depression as primary complaint. Evaluation of the postpartum female should include a complete history and a detailed account of the obstetrical situation, including delivery of the placenta. The female should be assessed by complete physical examination, CBC, blood chemistry, transabdominal and transrectal ultrasonography, and vaginal examination. Excessive fluid in the abdomen would warrant abdominocentesis.

4.17. Rectal–vaginal tear

Due to their small perineal body and powerful expulsive efforts, rectal–vaginal tear is common following overt obstetrical manipulations in camelids. A common cause of these tears is rapid vaginal delivery of the fetus without sufficient preparation of the vulva and vestibular area. Episiotomy should be considered in females with insufficient dilation of the vulva, particularly maidens. Cases seen in our practice are often a complication of fetotomy. Rectal–vaginal tears may be repaired immediately, or a few weeks later, after second-intention healing [41].

4.18. Uterine bruising and tear

Postpartum uterine tears are not as dramatic as in the mare, unless there is involvement of a large vessel or severe contamination of the uterus and peritonitis. Uterine bruising is often seen following excessive obstetrical manipulation (particularly fetotomy). Uterine involution is very rapid in the camelid and small, dorsal uterine tears may heal spontaneously; the only sequela may be infertility due to peri-uterine adhesions. Complications from uterine tears are often due to severe contamination, either during obstetrical manipulation or following partial or total retention of the placenta [62]. These females may initially appear comfortable, then slowly develop a fulminating peritonitis. Clinical signs of toxemia may appear within the first 24 h, but it may take as long as 3–4 days for the clinical picture to become recognizable. It is important that these cases be stabilized, with antimicrobial and anti-inflammatory therapy initiated at the first sign of compromise. Uterine lavage should be considered only after verification of the integrity of the uterine wall and should be monitored by transabdominal ultrasonography to visualize remnants of the placenta. A case of complete passage of the placenta into the abdominal cavity was described in a

llama with progressive deterioration of health, which eventually succumbed to peritonitis 11 days after dystocia [62].

It is not clear how uterine tears occur in camelids; although most are associated with obstetrical manipulation, we have seen cases following spontaneous and apparently uneventful parturition. Therefore, every female should be monitored to ensure delivery of the placenta, followed by inspection of the placenta to ensure that it is complete. The camelid placenta is epitheliochorial, mircocotytledonary and is rarely retained more than 36 h, even after dystocia.

If a uterine tear is detected in the early postpartum period by direct vaginal palpation, an attempt could be made to induce uterine prolapse after treatment with epinephrine and epidural anesthesia. Alternately, the uterine tear can be repaired after celiotomy. If the placenta is still present, it should be pealed from the endometrium around the tear before suturing. In cases of unexplained fever, abdominal pain or anorexia in the postpartum female, exploratory celiotomy or laparoscopy should be considered. Adjunctive therapy for peritonitis is indicated and should include abdominal lavage and systemic broad-spectrum antimicrobial and anti-inflammatory therapy, along with intravenous fluid therapy for cardiovascular support.

4.19. Postpartum hemorrhage

Postpartum hemorrhage from the uterine arteries is less common in camelids than mares. Most of the postpartum hemorrhage cases diagnosed by our group consist of rupture or laceration of the vaginal uterine artery. This artery is easily recognized by palpation per vaginum during obstetrical manipulation and is peculiarly large in camelids. Excessive manipulation, and in particular fetotomy, may cause erosion of the mucosa and laceration of the artery. Unfortunately, many of these hemorrhages are missed, as no outward signs are apparent until it is too late. Typically, blood accumulates within the uterus for a few hours, followed by cardiovascular collapse. In one case, the female was found dead in her stall 2 h after delivery. Ruptured vaginal arteries may be sutured and blood transfusion should be considered in females with a PCV $<10\%$. Packing of the vaginal with compresses, i.e. a device similar to the ''umbrella pack'' used in humans, may be helpful.

4.20. Uterine prolapse

Partial or total uterine prolapse occur secondary to dystocia, manual removal of a retained placenta, and excessive use of oxytocin (dose and frequency). Uterine prolapse is far more common in camels than in llamas and alpacas, and is often associated with hypocalcemia, selenium deficiencies, and retained placenta [49,50]. Dairy camels seem to be more prone to uterine prolapse [63–69]. Uterine prolapse occurs generally immediately (first 30 min) after parturition or abortion [50].

Techniques for replacement are similar to those reported in cattle and small ruminants, and are usually done under sedation and epidural analgesia. The placenta is often easily peeled off and should be removed if possible before 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. A Bühner suture is used in camels and a shoelace pattern can be used around the vulvar lips in alpacas and llamas. Uterine prolapse tends to re-occur if the uterine horns are not fully extended. Hysterectomy should be considered if the uterine tissue has sustained severe damage [8,31,70].

4.21. Rectal prolapse

Rectal prolapse has been reported in llamas and camels. Pregnant females with tenesmus and diarrhea are predisposed. Rectal prolapse can be intermittent. In a case of a dromedary female near term, rectal prolapse was noticed intermittently, without vaginal prolapse. Treatment of the underlying cause and surgical repair have been successful [3,71].

4.22. Other complications of the postpartum period

Emergency postpartum complications in camelids include a vast array of conditions which often manifest themselves as lethargy, depression and progress towards a downer female syndrome. The approach to diagnosis of the causes of downer syndrome is similar to that used in cattle [72]. Predisposing factors include septic metritis, necrotic vaginitis, retained placenta, hypocalcemia, dystocia, pelvic injuries, hemorrhage, and presence of compressive lesions. A milk fever syndrome (hypocalcemia), similar to the condition in dairy cattle, is also observed in dairy camels. Toxic mastitis has been described in dairy camels, but not in South American camelids [73].

In addition to physical evaluation, CBC and blood biochemistry, the evaluation of the downer postpartum

camelid should include transrectal and transabdominal ultrasonography and potentially collection and evaluation of cerebrospinal fluid. More advanced imaging techniques may be required in some cases in order to detect neoplastic masses. Although, retained placenta is not usually an emergency in camelids, failure of delivery of the placenta following a cesarean section may lead to severe complications.

Severe swelling of the vulva and vagina are painful conditions associated with overt obstetrical manipulation. Females experiencing these complications may have persistent straining and abandon their neonate. Untreated vaginal and cervical inflammation may lead to adhesions and development of pyometra. Females with severe inflammation of the birth canal should be treated with systemic and local anti-inflammatory drugs. Daily application of cold compresses and treatment with ointments with anti-inflammatory and antimicrobial properties may reduce inflammation and adhesions.

5. Neonatal emergencies

In an epidemiological study in the United Kingdom, 4–11% of deaths amongst llamas and 17–33% of deaths in alpacas occur during the first 6 months of life. A high proportion of these deaths occur within the first week of life [31,74]. In camels, neonatal mortality can reach 50% of the calf crop in the first 10 days of life [45].

Newborn morbidity and mortality is very high in the immediate neonatal (<1 week old) period following obstetrical manipulations, cesarean section, prematurity, or dysmaturity [75]. These losses are often due to complications from hypoxia, failure of passive transfer, and intrapartum infection. The clinical signs are often nonspecific and vague, resulting in an individual that is slow to adapt to extrauterine life, or that dies suddenly within the first few days of life. Infections may be acquired *in utero* or intrapartum, and should be suspected if the newborn has elevated plasma fibrinogen concentrations in the first 12–24 h of life, the placenta appears abnormal, or the dam exhibited uterine discharge peripartum [75]. Therefore, immediate identification and care of the newborn camelid at high risk for sepsis is an important part of reproductive emergencies.

The newborn should be evaluated within the first hours of life to detect any abnormalities of development or maladjustment to extra-uterine life. Physical and behavioral parameters of the normal newborn are shown (Table 1). Assessment of the newborn cria should include evaluation of the epidermal membrane and placenta, respiration, cardiac function, and the presence of obvious congenital abnormalities. The epidermal membrane, which is normally translucent, may become yellow or brownish due to meconium staining in case of fetal stress due to dystocia.

Many congenital abnormalities have been described in camelids, some of which can be lethal. Amongst the most important are: cleft palate, choanal atresia, atresia ani, and heart defects. The initial examination of the cria should establish if any of these abnormalities are present (Table 2), so they can be corrected early or a decision made to humanely euthanize the cria.

Neonatal cases are presented with a wide variety of nonspecific complaints based on deviations from the normal appearance and behavior presented above. The minimum database used to evaluate the cria include: evaluation of maternal transfer of immunogobulins, CBC (including differential count and determination of plasma fibrinogen concentration), arterial blood gas analysis, serum chemistry, and aerobic and anaerobic blood cultures. Contrast radiographs of the nasopharyngeal area may be indicated if choanal atresia is suspected as a cause of dyspnea [76].

Table 1
Biological parameters of normal healthy camelids

Parameter	Alpacas (*Vicugna pacos*)	Llama (*Lama glama*)	Camels (*Camelus dromedarius* and *C. bactrianus*)
Birth weight (kg)	7–11	9–15.5	30–50
Temperature (°C)	37.7–38.9		37.5–39.0
Pulse (bpm)	60–100		80–120
Respiration (bpm)	10–30		20–30
Time to standing (min)	30 (10–120)		30 (15–80)
Time to nursing (min)	45 (20–180)		30 (20–120)
Nursing frequency	Once an hour for 1–2 min		
Meconium passage (h)	18–24		<18
Urination (h)	18		<18

Table 2
Congenital abnormalities of camelids associated with emergencies or high mortality

Type of defect	References
Uro-genital defects, renal agenesis, atresia vulvi	[87,94,99–103]
Atresia ani	[87,104]
Cleft palate	[99,100,105]
Choanal atresia	[85,86,106] Tibary
Severe angular limb deformities	[99,100,107–109]
Severe umbilical hernia	[99,100] Tibary
Heart defects (tetralogy of fallot, ventricular septal defect)	[99,100,110]
Esophageal defect	[99,100]
Wry face	[99,100]
Diaphragmatic hernia	[111]

6. Management of the high-risk neonate

Any cria delivered before day 315 of pregnancy should be considered premature. Premature birth may be a consequence of a stressful illness during pregnancy or due to a decision to induce parturition because of severe compromise to the dam. Recently, the authors have seen a high rate of premature births following an outbreak of respiratory diseases. Premature birth may also be secondary to uterine pathology (i.e. placentitis or placental insufficiency) [77]. Premature crias display specific phenotypic characteristics, including a birth weight significantly (>20%) lower that that the average for the farm, and a thick epidermal membrane firmly attached to the foot pads and the mucocutaenous junctions. A ''floppy'' syndrome, often seen in premature camelids, includes inability to rise, to hold the head up, or to maintain sternal recumbency and floppy ears (new world camelids), due to immaturity of the cartilage. The coat appears silky and the limbs are overextended at the carpus and fetlock, due to laxity of the tendon and poor muscle tone. The incisors are not erupted and the suckling reflex is absent or weak.

Premature neonates adapt to extrauterine life very slowly. Due to the normal elevated fetal cortisol concentrations, they may appear healthy initially, but become comprised a few hours later due to developing metabolic problems. These problems are often due to hypoxemia, acidosis, hypoglycemia, and limited body reserves or poor thermogenic ability. Premature neonates are exposed to a wide range of respiratory and intestinal compromise due to immaturity of these systems. Respiratory distress may be notice by labored or even open-mouth breathing. This syndrome is likely due to lack of surfactants required for normal air sac expansions and inefficient oxygen absorption. Mortality rate is very high is these crias if they do not receive immediate attention [31,50].

Intestinal immaturity in premature crias predisposes them to failure of passive transfer, even if colostrum is ingested orally in the first hours of life (failure of absorption). They also tend to be more at risk for bloating and meconium retention due to poor gut motility.

Dysmature or hypoxic neonates are often the result of induction of parturition, severe illness during pregnancy, or prolonged gestation. They usually present with similar biophysical characteristics as the premature neonates, except that they may have normal body development.

Mature compromised crias are usually the result of lengthy obstetrical manipulation or delivery via cesarean section. The degree of compromise depends on several factors.

There is a complete lack of evidence-based medicine in emergency critical care of newborn camelids; most of the available information is anecdotal and based on clinical experience with other species. Premature or stressed neonates require intensive care in the first few hours of life. They should be placed immediately in a warm environment. Baseline CBC and blood biochemistry are indicated to determination status of hydration and electrolytes, blood glucose concentration, total protein and IgG at 24–36 h. At-risk patients should receive an intravenous plasma transfusion. If the suckling reflex is absent, tube feeding is necessary and should be restricted to small volumes every 2–3 h, to reach 10–15% of body weight by 24 h of life.

Oxygen supplementation may be required if respiratory distress is pronounced. Lung function should be monitored by blood gas analysis. Aminophylline, an adenosine A (2A)-receptor antagonist like caffeine, has been given for 3 days to stimulate the central nervous system and regulate breathing and to stimulate the type II pneumocytes to produce components for the surfactant production [78,79]. Intraoperational administration of aminophylline to the dam may be advantageous if a cesarean section is planned [79,80]. Doxapram is routinely used to stimulate the central nervous system and relieve neonatal apnea following dystocia or cesarean section [81,82]. We general administer a small dose sublingual (5 mg in llama and alpaca crias and 50 mg in camels) initially after a cesarean section or dystocia. In neonates with severely depressed respiration, this dose, or up to twice this dose, should be given IV or IV. The neonate should be monitored closely for convulsions or hyperventilation.

Sepsis is a major concern in all compromised neonates. In one study, the median age at presentation of

crias with sepsis was 2 days. Meningitis with severe clinical signs (opisthotonus, nystagmus, stiff legs, seizures, miosis) may occur early as 2 days of life. Hypopion, uveitis, or conjunctivitis indicate early septicemia. Compromised neonates should receive immediately antimicrobial therapy via intravenous catheter placed in the jugular or saphenous vein [75,76,83].

Both $Gram^+$ and $Gram^-$ organisms have been isolated from neonates with septicemia. Based on common isolates, the antibiotics of choice for camelids at high risk of sepsis include the following combinations (enrofloxacin and PPG, enrofloxacin and ceftiofur, ceftiofur and gentamicin) [75,76,83]. Gentamicin should be used with care, as it can be extremely nephrotoxic to severely dehydrated newborn camelids, or if there is already evidence of renal dysfunction. Blood cultures may be submitted, but broad-spectrum antimicrobial treatment should be started without delay.

Supportive treatment should include NSAIDs (ketoprofen 4 mg/kg SID) to control pain and toxemia and antiulcer medication (omeprazol, given orally, 2 mg/kg daily) to offset the effect of stress and NSAID. Intravenous fluid therapy is indicated in all dehydrated, hypoglycemic newborns, however caution should be exercised regarding the rate of fluid replacement, as camelids are prone to pulmonary edema. Severely dehydrated crias require fluid therapy. The type of fluid should be determined based on glucose, electrolyte and blood gas evaluation. Generally, a balanced isotonic solution with 2% dextrose and bicarbonate to correct metabolic acidosis are sufficient. Dextrose concentration may be increased to 5% in hypoglycemic crias. Rate of administration should aim to correct half of the deficit over the first hour, and the other half over the next 2 h. Total or partial parenteral nutrition should be considered in severely depressed crias that are unable to nurse [84]. Prognosis for life and normal growth depends primarily on the interval between birth and providing emergency care.

7. Other emergency problems in first 24 h of life

Diseases in the first 24 h of life are usually associated with congenital abnormalities, digestive (meconium retention), urinary problems (urine retention), exposure or malnutrition.

7.1. Congenital abnormalities

The most common lethal congenital abnormalities that affect the camelid neonate are: choanal atresia, atresia ani or coli, and heart defects. Most commonly, affected animals will suffer from severe respiratory, circulatory or metabolic complications. Heart defects can be very severe and lead to death of the cria within a few hours, but most will survive for a few days to months, with the only abnormality being failure to thrive. Syncope or fainting were observed in crias with severe heart defects.

Choanal atresia is the lack of opening of the nasal air passages, resulting from the presence at the level of the choanae of a membranous or osseous separation between the nasal and pharyngeal cavities [85,86]. Diagnosis can be confirmed by mouth to nose artificial breathing or by contrast radiographs of the head after injection of a radio-opaque substance in the nasal cavity. Maxillofacial agenesis or dysgenesis ''wry face'' is a head deformity characterized by varying degrees of deviation of the maxilla. This abnormality may be associated with choanal atresia. There is no treatment for this condition and the cria should be euthanized. Respiratory distress associated with congenital goiter has been described in camels [45].

Atresia ani and atresia coli are, respectively, the lack of opening of the anal sphincter and lack of connection between the colon and the rectal cavity. These abnormalities results in the blockage of the intestinal transit and accumulation of fluid in the gastrointestinal tract. The cria becomes progressively bloated and depressed. Ultrasonographic and radiologic examination of the abdominal cavity allows confirmation of the diagnosis. Atresia coli may be mistaken for meconium retention. In the female cria, these abnormalities may involve the genital tract. Surgical correction of the atresia ani has described [87].

Congenital blindness associated with different ocular defects has also been reported and will impact neonate behavior and wellness [88–90].

It is important that the practitioner established the diagnosis of congenital abnormalities with certainty, because some of these may be hereditary [91,92].

7.2. Meconium retention

Meconium is the amniotic fluid ingested by the fetus during pregnancy. Meconium is usually passed within 18–24 h after birth as dark pasty or stringy feces. Clinical signs of meconium retention include straining, squatting, tail wagging, anorexia, and signs of abdominal discomfort. Initial treatment consists of one or two warm soapy water enemas (20–40 mL). If after two enemas, the meconium has not passed, intravenous fluids may be indicated, as multiple soapy

Table 3
Formulary for emergency veterinary care of camelids

Drug	Llamas and alpacas	Camels	Remarks
Sedatives/anesthetics/analgesics and reversal agents			
Acepromazine	0.02–0.05 mg/kg IV, IM, SQ	0.05 mg/kg	Sedation, use with care if depressed or hypotensive. Avoid in an emergency
Butrophanol	0.05–0.1 mg/kg IM, SQ	0.05–0.2 mg/kg IM	
Ketamine	2–4 mg/kg IV 4–6 mg/kg IM	5–8 mg/kg IM	Avoid IV route if pregnant
Ketoprofen	2 mg/kg IV, IM, SQ	2–3 mg/kg	
Lidocaine 2%	1 mL/100 kg	1 mL/100 kg	Toxic dose 4 mg/kg
Talazoline	2–4 mg/kg IM, SC, IV	0.2 mg/kg IV	Cardiac asystole (give slowly)
Yohimbine HCl	0.125 mg/kg	0.25 mg/kg	
Neonatal resuscitation			
Aminophylline	2–4 mg/kg SQ	4–7 mg/kg	
Atropine	0.04 mg/kg IV, SQ	0.04 mg/kg	Bradycardia
Doxapram HCl	5–10 mg/kg IV, IM, sublingual	0.2–0.3 mg/kg	Use with caution
Diazepam	01.–0.2 mg/kg	0.1–0.2 mg/kg	
Xylazine	0.2–0.3 mg/kg IV	0.2 mg/kg	
Yohimbine	0.1 mg/kg IV, IM	0.125 mg/kg	Acute hypotension possible
Antimicrobials			
Ampicillin sodium	6–10 mg/kg IV q 8 h	6.6 mg/kg IV TID	
Ceftiofur (solution)	2 mg/kg BID	2 mg/kg BID	
Ceftiofur (suspension)	2.2 mg/kg SQ, IM SID	1–2 mg/kg, IM SID	
Enrofloxacin	5–10 mg/kg SQ SID	2.5–5 mg/kg	
Florfenicol	20 mg/kg SQ q 48 h	20–40 mg/kg SQ (single dose)	
Gentamicin	5 mg/kg SID	4 mg/kg IM BID	Nephrotoxic
Oxytetracycline LA	20 mg/kg IV SQ	10–20 mg/kg	Every 2–3 days
Procaine penicillin G	20,000 IU/kg SC or IM BID or SID	20,000 IU/kg BID	
Hormones			
Cloprostenol	250 μg IM	500 μg IM	
Misoprostol	400–600 μg cervical	1–2 mg	Topical for cervical dilation
Oxytocin	5–7.5 IU (alpaca) 5–10 IU (llama)	20–30 IU	IV drip (1 IU/min)
Hydroxyprogesterone caproate	250 mg	500 mg	Every 3 week (do not use last 4 week of pregnancy)
Anti-inflammatory drugs			
Flunixin meglumine	1 mg/kg IV or SQ, BID or SID		
Fluid therapy[a]			
Other useful drugs			
Clenbuterol[b]		300 μg once, IM or slow IV	Obstetrical manipulations
Diphenhydramine	0.5–1 mg/kg IM or IV		Anaphylactic shock
Epinephrine	1 mL/50 kg (1:1000 dilution)	0.01 mg/kg	Anaphylactic shock, myorelaxant
Insulin			
Omeprazole	2–4 mg/kg PO	2–4 mg/kg PO	
Vitman B complex[c]	5–10 mL adult	0.02–0.04 mL/kg	
Buscopan (juoscine-*N*-butyl bromide)		4 mg/mL; 1 mL/10 kg	Spasmolytic, analgesic

[a] Fluid therapy, the most common balanced salt solution used are LRS and normosol, bicabonate should be available to correct acidosis, dextrose can be used at 1.5–5% depending on degree of hypoglycemia. Fluids can be spiked (as needed) to correct hypocalcemia (calcium bromogluconate) or hypokalemia (KCl) or any other metabolic disturbance.

[b] Clenbutorol is not available in some countries, including the USA.

[c] Each mL contains: B1 (100 mg), B2 (5 mg), B3 (100 mg), B6 (10 mg), 1 D-pantheno (l0 mg), B12 (100 μg).

water enemas may irritate the rectal mucosa, resulting in severe straining and rectal prolapse [93]. Crias that have retained meconium may have other abnormalities and should be examined closely. Routine administration of enemas to every newborn cria should be discouraged.

7.3. Urine retention

Urine retention may be associated with congenital abnormalities of the urinary and genital tracts [94]. In males, urethral blockage (aplasia) results in bladder rupture. In females, vulvar agenesis or atresia vulvi present with an obvious bulging of the perineum and often symptoms of pain, due to the large quantity of urine in the uterus and abdominal distension [31,71].

7.4. Umbilical abnormalities

Accidents to the umbilical stump are not uncommon. The simplest form is persistent bleeding, which can be treated with hemostasis provided by a hemostat or sutures. Persistent urachus is not as common as in other species. Umblical hernia and rupture of the abdominal wall with eventration has been seen by the author following dystocia due to uterine torsion and may be due to wrapping of the cord around the fetus. These are easily replaced surgically.

7.5. Failure of passive transfer

Failure of passive transfer is a major cause of neonatal mortality in camelids [95]. Assessment of IgG concentrations can be performed 18 h after birth [96–98]. Serum total protein concentrations <5 mg/dL are also very indicative of failure of passive transfer. In these cases, hyperimmune plasma should be given IV or IP (15–25 mL/kg). Commercial products are now available (Triple J Farm, Kent Laboratories, 777 Jorgensen Place, Bellingham, WA 98226, USA). This product is collected from llamas regularly immunized with *Clostridium perfringens* type C, *Escherichia coli* bacterin-toxoid, *Clostridium chauvoeisepticum*, *Clostridium haemolyticum*, *Clostridium novyi*, *Clostridium tetani* and *Clostridium perfringens* types C and D bacterin-toxoid, killed Equine herpes virus-1, bovine rota-coronavirus modified live virus, J-5 *E. coli* bacterin, IMRAD 3 killed rabies vaccine, and inactivated cultures of *Leptospira canicola*, *Leptospira grippotyphosa*, *Leptospira hardjo*, *Leptospira ichterohaemorrhagiae* and *Leptospira pomona*.

8. Conclusion

Reproductive emergencies involve not only saving the health but also the reproductive future of the patient. Emergencies in the pregnant female present an additional challenge, in that the fetus has to be considered regarding response to treatment and viability. At times, it is important to make a decision as to which of the two (dam or fetus) has more economic or sentimental value, or chances to survive. One of the main challenges in emergency care in camelids is the lack of evidence-based scientific data on treatment and outcome assessment. Although extrapolation from other species has been possible, it is important to remember species peculiarities, especially with regard to fluid therapy. Handling of obstetrical situations is particularly important, as many female camelids loose their ability to reproduce due to iatrogenic vaginal adhesions and cervical trauma from prolonged manipulation.

In the male, hyperthermia (environmental or pathologic) is the leading cause of reproductive loss and client education regarding its prevention and early recognition is paramount for successful preservation of fertility.

Veterinarians involved in camelid practice, of which reproductive services (including reproductive emergencies and neonatology) represents over 70% of the complaints, should have a very good understanding regarding anatomical, physiological and medical peculiarities of camelids, and utilize their experience in other species. This makes an excellent point for the importance of comparative approach to training theriogenologists and large animal veterinarians. Emergency drugs and protocols (Table 3) should be in place to ensure timely delivery of critical care and improved outcomes.

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