Review Report

Cesarean section in camelids: indications, technique, survival, and postoperative fertility

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Abstract

Cesarean section is the most common surgery of the reproductive tract in camelids. However, limited information is available on indication, surgical approach, dam survival, postpartum complications, and neonatal survival following cesarean section in camelids. The objective of this study was to retrospectively evaluate medical records on 84 camels, 29 alpacas, and 3 llamas to evaluate the above factors. Incomplete cervical dilatation (56%; *n* = 65/84) and uterine torsion (59.4%, *n* = 19/32) were the most common indications for cesarean section in camels and South American camelids (SACs), respectively. The neonatal survival (SAC: 46.9%, *n* = 15/32; camels: 76.2%, *n* = 64/84) was acceptable, and postoperative fertility was excellent (SACs = 75.86%, camels = 72.6%).

Keywords: Camelid; dystocia; surgery; cesarean; postpartum

Introduction

Camelids present several gestation and parturition characteristics that distinguish them from other domestic animals. They demonstrate almost exclusively (~98%) left horn pregnancies,[1] epitheliochorial microcotyledonary placentation, and a short but explosive second stage (fetal expulsion) of labor. Following parturition there is rapid uterine involution, resumption of ovarian activity, and restoration of fertility within 2 weeks of parturition. Incidence of dystocia in camelids is reported to range from 2 to 8%.[2–4] Most cases of dystocia are resolved with non-surgical obstetrical manipulation.[3] Causes of dystocia reported in camelids include fetal maldispositions (head deviations, shoulder or carpal flexure, bilateral hip flexure), failure of cervical dilation, and uterine torsion.[2,4,5] Due to the diffuse placentation, premature detachment during dystocia can lead to fetal hypoxia followed by death or postnatal compromise. Because of this risk, dystocia in camelids should be handled with the same degree of urgency as for mares.[3] In addition, camelids have a narrow pelvic inlet and pelvic canal, and the cervix and vagina are more prone to laceration. Thus, per vaginum obstetrical manipulations should be limited in time and force because of the high risk for complications such as vaginal adhesions and cervical lacerations.[6] Fetotomy is often contraindicated, particularly in alpacas, leaving cesarean section as the only option to resolve dystocia when vaginal manipulation fails to deliver the neonate.[3]

Cesarean section is the most common reproductive emergency surgical procedure in large animal practice, including camelids.[7] In ruminants, cesarean section is common and carries a favorable prognosis for both the dam and the offspring. The most common indications for cesarean section in ruminants is feto-maternal disproportion, uterine torsion, and severe fetal maldisposition.[8–10] Similar indications have been proposed for camelids.[3,11,12] The surgical approaches for cesarean section in camelids include left flank (most common), low flank/ventrolateral and ventral midline (for llamas and alpacas only). In alpacas and llamas, a left flank or ventral midline approach can be used for cesarean section; however, a flank approach is recommended for field conditions and uncomplicated cases. A ventral midline approach under general anesthesia is recommended for cases of uterine torsion or cases of compromised uterine health. For camels, a higher left flank approach is recommended as compared to a ventrolateral (low flank) approach (described by Elias[13]) which predisposes to herniation.[7]

Postsurgical information on survival of neonates and dams and fertility post-cesarean section in camelids is limited.[14]

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The objectives of this retrospective study were to evaluate indications for cesarean section, surgical techniques employed, dam and neonatal survival rates, and postoperative fertility. Throughout the paper unless a specific species is mentioned, the term South American Camelids (SAC) will be used to refer to alpacas (*Vicugna pacos*) and llamas (*Lama glama*). The term camel will refer primarily to dromedary camels (*Camelus dromedarius*). The term camelids will be used to include all three species.

Materials and methods

Medical records from alpacas and llamas that were admitted to the Washington State University Veterinary Teaching Hospital (WSU-VTH) Comparative Theriogenology service for dystocia, medical records for alpacas from Mountain West Animal Hospital (MWAH), Springville, Utah, and medical records from camels from the Veterinary Research Center (VRC), Abu Dhabi (UAE) were reviewed. Only those alpacas, llamas, and camels having undergone a cesarean section (21 alpacas and 3 llamas at WSU, 8 alpacas at MWAH, and 84 camels at VRC) were included in this retrospective study. Information retrieved from the medical records included the age of the female at presentation (information on age of camels was not available), time to initial presentation, indication for cesarean section, anesthetic protocol, surgical technique employed, survival of the dam and neonate, postoperative complications, and postoperative fertility of the dam.

Follow-up information was obtained by email or telephone interview with owners. Owners were asked whether any complications developed after discharge from the hospital, the breeding history following discharge, whether dystocia occurred during subsequent pregnancies, if additional cesarean sections were performed in subsequent pregnancies, and the number of live neonates delivered in subsequent pregnancies. Follow-up information for camels was obtained through review of medical records of embryo transfer recipients 1-year after surgery. The only information available for alpacas from MWAH was age and parity of dam, cause of dystocia, postoperative complication, dam survival and fertility, and neonatal survival. All other relevant information on SACs was from WSU patients only.

Descriptive statistics were performed to determine the relative incidence of specific causes of dystocia, which led to cesarean section.

Results

Eighty-four camels, 29 alpacas (21 from WSU and 8 from MWAH) and 3 llamas met the inclusion criteria for the study. One alpaca underwent 2 cesarean sections (2 years apart) and both were included in this study. SAC females were either referred (45.8%; $n = 11$) or seen as a primary patient by the WSU-VTH Comparative Theriogenology service (54.2%; $n = 13$). Mean (± SEM) age of SAC females was 5.1 ± 0.47 years (range 2–10). Information on age of camels was not available. The proportions of maiden (46.8%, $n = 15$) and multiparous SAC females (53.2%, $n = 17$) were similar ($p > 0.05$). Majority of female camels (92.9%, $n = 78$) were multiparous and either bred naturally ($n = 11$) or received an embryo at 8 days post-ovulation ($n = 73$). The mean (± SEM) gestational age at the time of presentation for SAC was 353.8 ± 2.49 days (range 329–376). The mean (± SEM) gestational age at the time of presentation for camels was 376.1 ± 6.2 days (range 278–393) for naturally mated females and 374.1 ± 1.4 days (range 352–398) for embryo transfer recipients. The time to referral ranged from 0 to 72 h for SAC females. In camels, the time from observation of the second stage of labor to surgery was less than 6 h for embryo transfer recipients and between 8 and 48 h in naturally mated females.

Failure of cervical dilation was identified as the most common indication necessitating a cesarean section (56%; $n = 65$) followed by fetal maldisposition (22.41%, $n = 26$) and uterine torsion (19.82, $n = 23$). Failure of cervical dilation was the most common cause of dystocia (73.8%, $n = 62$) in camels. All the affected camels were part of a study on embryo recipients where pregnancy was maintained by daily progesterone injection until 2 weeks prior to the due date. The 2 remaining cases were alpacas, 1 of which demonstrated failure of cervical dilation due to fetal bilateral carpal flexure and ventral head/neck deviation.

Uterine torsion was the predominant cause of dystocia in alpacas and llamas (overall 59.4%, $n = 19$; alpacas 58.60%, 17/29; llamas 66.7%, 2/3). Uterine torsion was significantly less common in camels (4.8%; $n = 4$). Most SAC uterine torsions were clockwise (80%; 12/15) and the degree of uterine torsion ranged from 90 to 360 degrees. In cases of SAC uterine torsion, cesarean section was performed as a primary modality of treatment (73.68%, $n = 14$) or following failed rolling attempts (26.32%; $n = 5$). In 1 alpaca, the uterine torsion was resolved successfully with rolling technique; however, bilateral hip flexure of the neonate was detected resulting in a cesarean section. Another alpaca developed uterine torsion as a maiden and in a subsequent pregnancy, both resulting in cesarean section. She was not rebred following the second cesarean section. Other indications for a cesarean section in SACs included fetal maldisposition (25%, $n = 8$) and twins (6.3%, $n = 2$). Fetal maldisposition was the second most common indication for cesarean section in SACs and the maldispositions included fetal bilateral hip flexure, fetal lateral head/neck deviation and fetal bilateral carpal flexion. The 2 dystocias associated with a twin pregnancy were in 1 llama and 1 alpaca. In camels, 21.4% ($n = 18$) of the cesarean sections were performed due to dystocia by fetal maldisposition. Twin pregnancy was not an indication for any camel cesarean sections. Fetal maldisposition was also the second most common indication (21.4%, $n = 18$) for cesarean section in camels.

Pre-surgical hematology was performed in 87.5% ($n = 21$) of SAC cases at WSU only. Complete blood count (CBC) and serum biochemistry were performed in 71.4% ($n = 15$) of SAC cases, with only a packed cell volume (PCV) and total protein (TP) being performed in 28.6% ($n = 6$) of cases. The most common abnormalities identified were leukocytosis due to neutrophilia (80%; 12/15), elevated creatinine kinase (40%; 6/15), hypocalcemia (<9.0 mg/dL) (20%; 3/15), and elevated liver enzymes (13.3%; 2/15). Both cases demonstrating elevated liver enzymes pre-surgically demonstrated prolonged systemic clinical illness prior to surgery due to hepatic lipidosis. The first case was an alpaca that presented on referral for decreased appetite and lethargy of unknown duration. Hematology demonstrated leukocytosis due to neutrophilia, elevated fibrinogen, elevated gamma-glutamyl transferase (GGT), elevated aspartate aminotransferase (AST), elevated alkaline phosphatase (AP), and hyperglycemia. Following hospitalization parturition was induced with

250 mcg cloprostenol, IM (Estrumate®, Merck, Madison, NJ) Cesarean section was performed because of lack of progression and evidence of fetal death and placental detachment. The female was non-responsive following anesthesia and was euthanized shortly after completion of surgery. The second case was an alpaca that was hospitalized for monitoring following diagnosis of *a* < 180-degree counterclockwise uterine torsion. During hospitalization, the female demonstrated progressive anorexia and development of hypoglycemia, elevated AST, and elevated GGT. Supportive care was initiated, and parturition was induced using 250 mcg cloprostenol, IM. A cesarean section was elected due to failure to progress to the second stage of labor 24 h after induction. The female and neonate were discharged from the WSU-VTH without further complications.

Cesarean section was performed via left paralumbar fossa approach (80.17%; *n* = 93: 84 camels, 7 alpacas, 2 llamas) or ventral midline approach (19.83%; *n* = 23; 22 alpacas, 1 llama). All camel cesarean sections used a left paralumbar fossa approach. In contrast, a ventral midline approach was used for 71.86% (*n* = 23/32) of SAC cases. Detailed data on anesthetic management was available for 87.5% (*n* = 21) of SAC cases at WSU. Sedation prior to anesthesia was used in 57.1% (12/21) of cases. Sedation consisted of 0.05–0.1 mg/kg butorphanol tartrate IM (Torbugesic®, Zoetis, Kalamazoo, MI) (29.2%; 7/21) and/or 0.11–0.2 mg/kg diazepam IV or IM (Diazepam, Dash, Upper Saddle River, NJ) (20.8%; 5/21). Anesthesia was induced using Propofol (0.6–2 mg/kg, IV; PropoFlo®, Zoetis, Kalamazoo, MI) (57.1%; 12/21), guaifenesin (1–1.5 mg/kg 10% solution, IV; Guaifenesin®, Wedgewood, Swedesboro, NJ) (4.8%; 1/21), ketamine (2–6 mg/kg, IV or IM; Ketaset®, Zoetis, Kalamazoo,MI) (4.8%; 1/21), guaifenesin (Guaifenesin®, Wedgewood) + ketamine (Ketaset®, Zoetis) (14.3%; 3/21), or masked inhalation of an anesthetic agent in oxygen (19%; 4/21). All SAC females were intubated with an endotracheal tube and maintained on isoflurane (Isoflurane, Piramel, Talangana, India) (85.7%; 18/21) or sevoflurane (Sevoflurane, Akron, Lak Forst, IL) (14.3%; 3/21) in oxygen. In all camel cases (100%; *n* = 76) surgery was performed with the female restrained in sternal recumbency. Sedation was obtained with xylazine (0.25 mg/kg, IV; AnaSed®, Akorn, Lake Forest, IL) alone or in combination with butorphanol (0.05 mg/kg, IV; Torbugesic®, Zoetis). Local analgesia was provided with an inverted L block using lidocaine (4–5 mg/Kg; Lidocaine, VETone®, MWI, Boise, ID). Caudal epidural analgesia with lidocaine (0.2 mg/Kg; Lidocaine, VETone®, MWI) was performed on only 7.9% (6/76) of camels. The flank procedure is performed in sedated and sternally restrained (cushed) animal using an inverted 'L' block local anesthesia. An oblique incision parallel to the direction of the quadriceps in the 'cushed' animal is made, on an imaginary line drawn from the tuber coxae to the base of the last rib, in the paralumbar fossa. A single-layer inverting pattern for uterine closure is suggested in cases where healthy uterine tissue is present and double-layer closure is recommended in cases where the uterus is compromised. Retained fetal membranes, incisional infection, herniation, peritonitis, intestinal adhesions, and infertility are the most common postoperative complications. Herniation and incisional infection due to myasis are especially common in camel cesarean sections performed in the field conditions.[7]

Overall dam survival rate was 91.38% (*n* = 106) and was similar for SAC (90.6%; *n* = 29) and camels (91.7%; *n* = 77). Causes of death included peritonitis (*n* = 3), septic metritis (*n* = 2), and 1 case each of anesthetic complication, vaginal evisceration, and systemic compromise. The most frequent non-lethal postoperative complications were retained placenta (failure to deliver the placenta within 6 h of surgery) (15.5%, *n* = 18; SAC 12.5%, *n* = 4; camels 16.7%, *n* = 14), surgical site infection or dehiscence (12.07%, *n* = 14; SAC 3.1%, *n* = 1; camels 15.5%, *n* = 13; mostly due to myiasis) and metritis (6.03%, *n* = 7; SAC 3.1%, *n* = 1; camels 7.1%, *n* = 6). In camels, complications from incisional site dehiscence due to maggot infestation were reduced with administration of local and systemic ivermectin treatment. Other complications included one case each of radial nerve paralysis, sepsis, anemia, and anorexia. Radial nerve paralysis and sepsis occurred in the same case. Anorexia was observed following accidental laceration of the small intestine during cesarean section in 1 alpaca. The laceration was surgically repaired, and subsequent peritonitis was not observed. All postoperative complications in SAC resolved prior to discharge. One alpaca developed clinical endometritis after discharge from the hospital and was successfully treated on the farm. Neonatal survival was 68.1% (*n* = 79) with 46.9% (*n* = 15/32) for SACs and 76.2% (*n* = 64) for camels. In SAC, 86.7% of the neonates were delivered alive but 1 was euthanized (demonstrated signs of prematurity) and 1 died (demonstrated signs of dysmaturity and respiratory distress) within 24 h following delivery. Camel calf viability at delivery, after 1-week of life, and at weaning was 81.6%, 75% and 73.7% respectively. Complete placental separation was present in all camel cases where the calf was delivered dead or died within 15 min after surgery. Causes of death in the first week included sepsis (*n* = 2), encephalopathy (*n* = 2) and trauma (*n* = 1).

Overall postsurgical fertility was 73.28% (*n* = 85). Postsurgical fertility was 75.86% in SACs with at least 1 offspring being born following cesarean section. Of the surviving SAC females (*n* = 29) reproductive records were available for 21 females following cesarean section. The owners reported no complications following patient discharge from the WSU-VTH. Breeding information was not available on five SAC females because they were sold (*n* = 2), retired from breeding following cesarean section (*n* = 2), or had not been rebred at the time of follow-up (*n* = 1). Postsurgical fertility was 72.6% for camels. Of the surviving camels (*n* = 77), 48 were used as recipients in an embryo transfer program 1-year after surgery. Of those, 70.8% (*n* = 34) became pregnant following 1 to 3 embryo transfers. Other camel pregnancies were by natural mating. Overall, postsurgical lifetime pregnancy establishment was not different between SAC (75.86%) and camels (70.8%).

Discussion

Dystocia is relatively rare in camelids but constitutes the majority of reproductive emergencies in these species.[2,3,5,7] In cases of dystocia the health and welfare of both the dam and the neonate must be considered.[2] There are limited studies evaluating factors associated with cesarean section and outcome in camelids. Dystocia of fetal origin seems to be more frequent in camels than in SAC. Most of the dystocias of fetal origin are due to postural abnormalities. Although twinning is rare in camelids,[2] 2 cases of twins resulting in a cesarean section were observed each in an alpaca and llama in this study. These findings are consistent with other retrospective study in SACs;[14] however, in that study a higher percentage of failure of cervical dilation in SACs was observed compared to our study. Failure of cervical dilation has been associated with progesterone supplementation during pregnancy in camelids.[15]

The survival rate of SAC females in our study was slightly higher (90.9%) than in the retrospective study by Miller et al (88%).[14] Overall survival rate for camels and SAC was similar to those reported for ruminants (81 to 97.8%) in uncomplicated cases.[16,17] Survival rates in referral centers can be higher even in complicated cases because of the availability of more advanced care.

Fetal viability of SAC in this study (46.9%) is slightly lower that that reported by Miller et al. (59%).[14] This could be due to differences in management of dystocia and time to presentation. In our conditions, most dystocia cases present after owners and referring veterinarians have attempted manipulation and the fetus is already dead at presentation to hospital. Transportation time for patients traveling to the WSU-VTH can also be extensive in some cases, resulting in fetal death prior to the cesarean section being performed. It is important to note that in cases where the neonate was deemed alive via transabdominal ultrasonography directly prior to the cesarean section survival rate was good (86%). Neonatal survival rates in other species following cesarean section are variable. Ruminants have good fetal survival rate because the second stage of parturition is normally longer.[17] In contrast, the percentage of foals delivered alive following cesarean section due to dystocia is very low (11–25%), with survival rates to discharge ranging from 5 to 25%. The foal survival in elective cesarean was 58% compared to 25% for cesareans following a dystocia.[18] Foal survival is affected by the time from dystocia to cesarean. When duration of stage II increases beyond 40 min, the incidence of stillbirth and foal mortality post-delivery significantly increases.[19] This low survival rate in equine fetuses in cases of dystocia is due primarily to fetal hypoxia due to placentation separation.[18] A similar trend exists in camelids which also have a microcotyledonary diffuse placentation. Miller et al. reported no significant relationship between the presence of uterine torsion and fetal death.[14] Similarly, in the present study 57% of the neonates delivered by cesarean section following a uterine torsion were discharged alive from the death.

Retained fetal membranes is described as the most common post-surgical complication in all large domestic animals.[8,9,16–18] In the present study the incidence of retained fetal membranes was 15.5% which is considerably lower than that reported (88%) in the only other study on cesarean section outcome in SAC.[14] There may be a difference in the duration of time following surgery to define the presence of retained fetal membranes between these studies. Our criterion was to classify retained fetal membranes if fetal membranes were still present more than 24 h following surgery. In most cases, we observed expulsion of the fetal membranes within 24 h without intensive management. Possibly Miller et al.[14] used a more traditional definition of retained fetal membranes where the placenta is considered retained after 3 h. Alternatively, this difference may reflect the fact that a significant number of our cases were in an advanced stage of placental detachment upon presentation. Additionally, the higher incidence of retained fetal membranes observed in camelids in the Miller et al[14] study may be due to the higher percentage of failure of cervical dilation observed in their dataset. It is important to note that retention of the fetal membranes was not detrimental to dam survival rate or postsurgical fertility.

There is limited information regarding the postoperative fertility in camelids following cesarean section. In ruminants, the prognosis for post-surgical fertility is generally good.[17,20,21] In mares, postoperative foaling rates are considerably decreased (<40%) in the first year after cesarean section. However, foaling rate tend to improve in subsequent years.[18] In our study, 75.86% of the SAC females that were rebred, conceived, and delivered a live neonate compared to 90.5% in another retrospective study on llamas and alpacas.[14] The reason for this discrepancy is not clear. In camels, there are no other reports on post-cesarean section fertility. Overall, in absence of complications, the prognosis for fertility after cesarean section in camelids seems similar to that of ruminants.

Conclusion

This retrospective study demonstrates that survival of the dam and neonate is excellent following cesarean section if intervention is early. Cesarean section in camelids can be considered as a field procedure as in ruminants. Dystocia due to failure of cervical dilation and uterine torsion were the most common indications for cesarean section in camels and SACs, respectively. The high rate of failure of cervical dilation in this case series is likely due to the maintenance of pregnancy with exogenous progesterone administration. Postoperative fertility following cesarean section is generally good, but more observations are needed to determine risk factors for loss of fertility and neonatal survival.

Conflict of interest

Authors disclose no conflicts of interest.

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