In South American camelids, dystocia is a rare occurrence (1% to 5%). Reported causes for dystocia in South American camelids are abnormal fetal position or presentation, failure of cervical dilatation, uterine torsion, uterine inertia, and uterine rupture. Twin pregnancies are rare and can potentially result in dystocia. Different surgical approaches for a cesarean section in cases of dystocia have been described. Although the technique for cesarean section in South American camelids is well described, information pertaining to postoperative complications and subsequent fertility following cesarean section has not been described to our knowledge. The purpose of the study reported here was to determine indications for cesarean section in alpacas and llamas undergoing cesarean section.

Objective—To determine indications for cesarean section in alpacas and llamas, and clinical management and outcome of alpacas and llamas undergoing cesarean section.

Design—Retrospective case series.

Animals—27 alpacas and 7 llamas.

Procedures—Medical records were reviewed and information gathered on signalment, anamnestic reproductive history, physical examination findings, indication for cesarean section, anesthetic protocol, surgical technique, number of crias delivered (alive or dead), additional treatment, duration of hospitalization, and postoperative complications. Follow-up information was gathered via email or telephone interview with owners.

Results—Uterine torsion (13/34 [38%]) was the most common reason for cesarean section. The most common surgical approach was the left proximal lateral abdominal approach (21/34 [62%]). Thirty-four crias were delivered via cesarean section. Twenty (59%) were born alive and discharged from the hospital. Retained placenta was the most common complication observed after surgery. A significant association was found between prolonged dystocia and fetal death. Of the 34 dams that underwent cesarean section, 21 were rebred, and 19 of the 21 (90.5%) dams that were rebred became pregnant. Fifteen of 19 dams were confirmed to have ≥1 normal vaginal delivery with a live cria following cesarean section.

Conclusions and Clinical Relevance—The results of the present study indicated that cesarean section was an effective method of resolving dystocia in camelids without negatively affecting future fertility or parturition by the dam. Prompt referral of patients with dystocia is advised to improve fetal viability. Retained fetal membranes seemed to be a common complication of cesarean section in camelids but was not associated with negative outcomes.

Materials and Methods

Criteria for selection of cases—Medical records of all alpacas and llamas admitted to 3 veterinary medical teaching hospitals between January 1997 and July 2010 were reviewed. Only the animals that had undergone a cesarean section were included in this retrospective study.

Medical records review—Information retrieved from the medical records included signalment, anamnesis including reproductive history, physical examination findings including a reproductive examination, indication for cesarean section, anesthetic protocol, surgical technique, number of crias delivered (alive or dead), additional treatment including duration, duration of hospitalization, and postoperative complications. The reproductive examination included an inspection of the perineal area to characterize the vulva, visualization, and condition of the fetus if possible and a description of any vaginal discharge. During vaginal examination, an assessment of the vagina, an assessment of the cervix, and an evaluation of fetus or fetuses were performed. Prolonged dystocia was defined as dystocia lasting >6 hours before admittance to the hospital. Complications were classified as either minor or major. Minor complications were defined as an adverse problem that did not require surgical intervention and was not life threatening. Major complications were defined as an adverse problem that posed a threat to the dam or calf and required surgical intervention.
required surgical intervention, was life threatening, or resulted in a poor outcome such as death.

Follow-up information—Follow-up information was obtained via email or telephone interviews with the owners. Specifically, the owners were asked whether they were satisfied with the outcome for their animals, whether any complications developed after discharge from the hospital, the breeding history following discharge, whether dystocia occurred during subsequent pregnancies, whether these pregnancies required cesarean section, and whether the cria survived delivery or had any complications.

Statistical analysis—A 2-tailed Fisher exact test was used to determine whether there were any differences between groups. Comparisons were made between surgical approach and the development of postoperative complications, between having a dead cria and developing postoperative complications, and between a dead cria and developing a retained placenta. Associations of prolonged dystocia, uterine torsion, malposition of the fetus, and inadequate dilation of the cervix with fetal death were also assessed as well as an association between a dead fetus in utero and death of the dam. Results were deemed significant at \( P \leq 0.05 \). Statistical analyses were performed with commercial software.

Results

Animals—Thirty-four camels had a cesarean section performed and met the inclusion criteria for this study. The cases came from 3 university hospitals: The Ohio State University (n = 20), University of Wisconsin (9), and Kansas State University (5). Of those 34 camels, 27 (79%) were alpacas and 7 (21%) were llamas.

Median age of the alpacas that underwent a cesarean section was 3 years (range, 2 to 12 years). Median age of the llamas that underwent cesarean section was 5.5 years (range, 4 to 7 years). The median weight of the dams was 83 kg (183 lb; range, 48 to 109 kg [106 to 240 lb]) for alpacas and 130 kg (330 lb; range, 125 to 173 kg [275 to 385 lb]) for llamas. Ten of the alpacas and llamas that underwent cesarean section were primiparous, 16 were multiparous, and the status of 8 was unknown. Two alpacas had previously undergone a cesarean, although the reason for the previous cesarean section was unknown. Other previous reproductive problems included 2 cases of dystocia and 1 case of late-term abortion.

History—Reasons for cesarean section included uterine torsion (n = 13 [38%]), malposition of the fetus (6 [17.5%]), inadequate dilation of the cervix (6 [17.5%]), vaginal stricture (2 [6%]), and uterine torsion with inadequate dilation of the cervix (1 [3%]). Other reasons included failure to progress in stage 2 labor (n = 1 [3%]), dystocia of unknown cause (1 [3%]), fetal malposition (1 [3%]), and emergency cesarean section (1 [3%]). In 3 cases, the animal was in hemorrhagic shock as a result of trauma or by a collision with a car (1 [3%]).

In alpacas, uterine torsion was the most common reason for cesarean section (13/27 [48%]). In llamas, malposition of the fetus was the most common reason for cesarean section (2/7). The duration of dystocia prior to hospital admission was available for all 34 camels. Fourteen were reported to have had a cesarean section because of uterine torsion or fetal viability concerns, and 20 were reported to have had a cesarean section because of true dystocia with active labor. Of those 20 camels, 11 were in stage 2 labor for < 6 hours, 6 were in stage 2 labor between 6 and 12 hours, and 3 were in stage 2 labor for > 12 hours. Nine of the 20 (45%) camels were considered to have prolonged dystocia. In all animals, the decision to perform a cesarean section had been made on the basis of a determination that vaginal delivery would be unsuccessful and the economic value of the dam and fetus was high.

Reproductive examination—Of the 34 camels, 3 (9%) had mucomucoid to serosanguineous vaginal discharge, and 2 (6%) had vulvar edema. A vaginal examination was completed after aseptic preparation of the vulva, and assessment was enhanced by the use of a speculum and ultrasonography. Any excessively straining animals were given a 1- to 3-mL caudal coccyeal epidural injection of 2% lidocaine. Of the 34 camels, only 18 had the results of a vaginal examination recorded. The findings during that examination were as follows: 10 (29%) had a palpable fetus, 5 (15%) had a closed cervix, and 3 (9%) had vaginal stricture. Fetal viability was assessed through transabdominal ultrasonography in 17 cases and by manual palpation of fetal movement in 10 cases during the vaginal exam; fetal viability was not assessed in 7 cases. At the time of initial examination, 18 of 34 camels had a confirmed viable fetus, and 6 camels were confirmed nonviable; viability could not be confirmed in 10 camels.

Surgical approach—One of the anesthesia techniques used comprised sedation with a combination of butorphanol tartrate (0.1 mg/kg [0.045 mg/lb], IV) and xylazine hydrochloride (0.3 mg/kg [0.14 mg/lb], IV) as well as a local block with 2% lidocaine hydrochloride (n = 16 [47.1%]). Of those 16 local blocks with lidocaine infiltration, 11 were line blocks, 4 were lumbosacral epidural blocks, and 1 was a combination of a lumbosacral epidural block and a line block. General anesthesia was another anesthesia technique performed with either sevoflurane or isoflurane in oxygen (n = 15 [44.1%]). The medical records of 3 (8.8%) camels did not indicate the anesthesia technique used.

The most common surgical approach was the left proximal lateral abdominal approach\(^2\)–\(^7\) (21/34 [62%]). Other approaches included ventral midline\(^2\)–\(^3\) (11/34 [32%]), paramedian (1/34 [3%]), and right proximal lateral abdominal (1/34 [3%]). The surgical approach used for the cesarean section had no significant (\( P = 1.0 \)) effect on the development of postoperative complications.

In only a small number of cases were abnormalities found during surgery involving the urogenital tract. These abnormalities were as follows: dark black amniotic fluid (n = 1), atonic uterus (2), and uterine rupture (1). A rectal tear was noted in 1 case and was repaired transrectally during surgery. The abdomen was lavaged multiple times during the laparotomy for cesarean section, and no complications developed in this case.

Postparturient care of the offspring—A complete physical examination was performed after the birth of
each cria, and care was taken to detect any congenital abnormalities and to remove fluid by suction to ensure a patent airway. To encourage breathing, crias were rubbed vigorously with a towel. All were supported with oxygen through nasal intubation, and any other problems were treated as needed.

**Postoperative care of the dams**—Antimicrobials were administered to all 34 dams. The antimicrobials used were ceftiofur sodium (2.2 mg/kg [1 mg/lb], SC, q 12 h), potassium penicillin (22,000 U/kg [10,000 U/lb], IV, q 6 h), amikacin (12 mg/kg [5.5 mg/lb], IV, q 24 h), ampicillin (20 mg/kg [9.1 mg/lb], IV, q 8 h), cephazolin (20 mg/kg [9.1 mg/lb], IM or IV, q 6 h), and gentamicin sulfate (6.6 mg/kg [3 mg/lb], IV, q 24 h). These antimicrobials were used alone (ceftiofur sodium [n = 24], potassium penicillin [2], ampicillin [1]) or in combination (potassium penicillin and ceftiofur sodium [4], potassium penicillin and ceftiofur sodium and amikacin [1], potassium penicillin and gentamicin [1], and gentamicin and cephazolin [1]). Flunixin meglumine (1.1 mg/kg [0.5 mg/lb], IV or IM, q 12 h) was administered to 33 dams before or after surgery for analgesia and anti-inflammatory effect. Retained fetal membranes were diagnosed after surgery when the membranes were not passed within 6 hours. This complication was noted in 30 (88%) of the camels. After surgery, treatment aimed to facilitate uterine involution or fetal membrane elimination was used in all 30 alpacas and llamas. Of these 30 cases, 26 were treated with cloprostenol (250 μg, IM) on the day of surgery, and if the membranes were not expelled within 24 hours, oxytocin (5 to 10 U, IM, 2 to 4 times in a 12-hour period) was given until the membranes were expelled. The remaining 4 animals were given oxytocin (5 to 30 U, IM or IV) during surgery or every 4 hours after surgery until the membranes were successfully expelled. Intravenous fluids were administered to the dam when indicated. Alpacas and llamas remained hospitalized for a median of 3 days (range, 2 to 11 days) before being discharged to the care of the owner.

**Fetal viability following surgery**—Thirty-four crias were delivered via cesarean section. Of these, 20 (59%) were born alive and discharged from the hospital, and 14 (41%) were born dead or died shortly after birth. Ten of the 14 crias that died either were confirmed dead at the time the dam was initially examined, or died prior to extraction from the uterus. Of the 14 alpacas and llamas that had a stillborn fetus, 4 were primiparous, 7 were multiparous, and 3 were unknown. Fetal death was significantly (P = 0.02) associated with prolonged dystocia. Other causes of fetal death included prematurity of the fetus (1), congenital malformation (1), and severe trauma (1). In 3 cases, the cause of death of the fetus was unknown.

In 3 cases, the dam had a dead cria and, subsequently, the dam died because of postoperative complications. Dams with a dead cria in utero were not significantly (P = 0.06) more at risk of death due to postoperative complications, compared with dams with a live cria in utero. Fetal death in dams having uterine torsion, inadequate dilation of the cervix, or malposition of the fetus was not significantly different, compared with dams not having these conditions (P = 0.08, 1.0, and 0.06, respectively).

**Complications**—Thirty (88%) camels had at least 1 complication, and 4 (12%) had no complications. Of the 30 camels that had complications, all had minor complications, and 5 had both minor and major complications. Of the animals that developed minor complications, some developed more than 1 minor complication after surgery. After discharge from the hospital, 2 animals developed additional complications (1 minor and 1 major), according to their owners. Minor complications noted were retained fetal membranes (n = 30), abdominal incision infection (2), metritis (2), anorexia (1), vaginal mucosal tears (1), severe leukopenia (1), uterine abscess (1), severe vulvar edema (1), abdominal incision edema (1), and pregnancy toxemia with both vaginitis and hyperglycemia (1). Retained fetal membranes was the most common complication seen after surgery (n = 30 [88%]). Patients with a dead cria were not at greater risk of developing retained fetal membranes (P = 0.38), and most of the camels with retained fetal membranes had no systemic signs of illness during their stay in the hospital.

Of the 14 alpacas and llamas that had dead crias, all had minor complications, and 4 also had major complications following surgery, but this was not significant (P = 0.13).

Of the 5 (17%) alpacas and llamas that had major complications, 1 had an incisional hernia, 1 developed a uterine prolapse, 1 was affected by peritonitis, 1 had hemorrhagic shock, and 1 developed severe bacterial pneumonia with peracute sepsis. Of the 5 animals that had major complications, 3 died as a result of their complications. Two of those animals died while they were still in the hospital (hemorrhagic shock and sepsis), and 1 died of septic peritonitis 2 weeks after being discharged from the hospital. The animal that died because of hemorrhagic shock was initially examined at our hospital in shock due to trauma caused by a collision with a car. This animal had a terminal cesarean section performed, and therefore, the condition of hemorrhagic shock was not related to the surgery itself.

**Follow-up results**—Of the 32 dams that were discharged from the hospital, long-term (range, 2 to 10 years after cesarean section) follow-up information was obtained from the owners of 24 (75%) dams. Breeding information or breeding performance was not available on 3 of the dams because they were sold (n = 1), retired from breeding (1), or had not been bred yet at the time of the follow-up (1). Of the 21 dams that were bred after cesarean section, 2 (9.5%) were unable to conceive, and 19 (90.5%) had become pregnant. The 19 camels that were bred were successfully bred after a 2- to 6-month voluntary waiting period after surgery. One of the dams that was unable to conceive died of unknown causes approximately 1 year after surgery. Of the 19 camels that were bred successfully, 16 (84%) had at least 1 normal vaginal delivery with a live cria. For the other 4 animals, the delivery type was unknown in 1, 1 had a dystocia of unknown cause, and 1 died of unknown causes before delivery. There was 1 dam that had 5 subsequent cesarean sections in consecutive years, followed by a natural vaginal delivery in the sixth year after surgery. The location where these subsequent cesarean sections were performed is unknown. All 6 of those crias were born alive. The reason for this animal’s cesarean sections was unknown, although the initial ce-
cesarean section was an elective procedure. Of the dams that were bred successfully following cesarean section, 10 have since produced multiple crias, suggesting that long-term fertility was not significantly negatively impacted by the surgery. Twenty-four of the 32 owners from whom follow-up information was obtained thought that a cesarean section was the correct way to resolve the dystocia in their animal and were very satisfied with the surgical treatment given to their animal. Few complications were noted after the animals were discharged from the hospital.

**Discussion**

The present study found that cesarean section is an effective method of resolving dystocia in cameldids with no apparent negative effect on future fertility or parturition by the dam. Retained fetal membranes was a common complication but was not associated with negative outcomes. The most common indications for cesarean section in alpacas and llamas in our study were uterine torsion, malposition of the fetus, and inadequate dilation of the cervix. These findings are consistent with the literature for the most common causes of dystocia in camelids. Uterine torsion, malposition of the fetus, and inadequate dilation of the cervix are generally regarded as having an increased risk of fetal death. The results of this study supported this opinion with regard to uterine torsion and fetal malposition. Thus, prompt surgical intervention via cesarean section is indicated when the uterus is in question or any abnormalities are noted that prohibit access to and ability to exteriorize the gravid horn of the uterus.4 Because of its lateral location, the spleen is located cranially along the lateral aspect of the rumen, is encapsulated, and is protected by the ribcage. In alpacas and llamas, the spleen is located caudal to the last rib and is attached to the lateral aspect of C1 but is not encapsulated. Because of its lateral location, the spleen may be near or underlying the approach to the lateral abdomen, risking iatrogenic trauma during laparotomy incision. Also, most cameldid pregnancies occur in the left horn. Thus, the left lateral approach presents an advantage because the access to and ability to exteriorize the gravid horn of the uterus is easier and the risk of abdominal contamination with uterine contents during the hysterotomy is less likely.3 In cows, a standing left-sided approach is performed for similar reasons, and a left oblique flank approach can facilitate removal of a large calf and contaminated uterus.13 This approach can also be performed without the use of general anesthesia and with no endotracheal intubation, making it more conducive to field emergencies. An additional benefit is that the risk of aspiration of ruminal contents is of less concern, compared with ventral midline and paramedian approaches.

All 34 of the dams in this study received antimicrobials prophylactically or for treatment of acquired complications. The complications of clinical concern included retained fetal membranes, metritis, peritonitis, and infectious infection. The most common bacteria to be isolated from the normal postpartum uterus of a llama and alpaca are *Actinomyces (Arcanobacterium) pyogenes*, α-hemolytic *Streptococcus* spp, and *Escherichia coli*. Broad-spectrum antimicrobials with both gram-positive and gram-negative spectrums are most commonly used. Furthermore, use of aminoglycosides is very controversial in food animals, and we recommend not using antimicrobials with long withdrawal times if any of the animals could be used as a meat source.
Retained fetal membranes was the most common complication in this study (30/34 [88%]). Fetal membrane retention in cows having cesarean section ranges between 35% and 40.8%, and in small ruminants, it was reported in 45% of sheep and goats undergoing a cesarean section.\(^6\)\(^,\)\(^7\) In mares, which have a more analogous placentaion to camelids than ruminants, the fetal membranes were retained in 65% of mares that had a cesarean section performed.\(^8\)\(^,\)\(^9\) Because of the lack in number of camelid cesarean sections reported in the literature, it is difficult to compare our percentages of postoperative complications, such as retained fetal membranes, to others. In 1 case study,\(^4\) 4 of 6 camelids had retained fetal membranes after undergoing cesarean section. In contrast to ruminants and horses, our clinical experience suggests that retention of the fetal membranes is of short duration, and the results of this study show that retention of the fetal membranes is not commonly associated with complications detrimental to dam survival rate or fertility. Administration of cloprostenol and oxytocin was sufficient for the treatment of retained fetal membranes in our cases, as has been shown in other ruminant species.\(^10\)\(^,\)\(^11\)

An important note is that the prostaglandin of choice in alpacas and llamas is cloprostenol because no adverse effects have been observed with its use. We have observed administration of prostaglandin \(F_2\alpha\) in llamas to cause death, the mechanism of which is believed to be extreme hypertension resulting in cardiac failure. It is also appropriate to be judicious when administering oxytocin because it may cause signs of abdominal pain in alpacas and llamas.\(^4\) We believe the incidence of retained fetal membranes can be reduced by a decrease in the amount of time the dam is in dystocia. It has been reported in ewes that weak or decreased uterine contractility can lead to more parturition assistance and place them at higher risk of retaining fetal membranes, especially if the fetus is dead.\(^12\) If prompt intervention is performed during a dystocia, uterine inertia and possibly a dead cria can be prevented. Patient morbidity associated with retained fetal membranes was minimal in this study.

Three camelids died because of a major complication after surgery. One alpaca that had a dead cria at the time of surgery died of severe peritonitis. Even though peritonitis is a potential major complication after any cesarean section,\(^3\) an early decision for cesarean section, especially while the fetus remains viable, and use of aseptic technique with careful surgical manipulation of tissues minimize the risk.\(^13\) Of the 2 other llamas that died, 1 died of unrelated traumatic injury sustained before admission to the hospital and 1 of severe bacterial pneumonia with peracute sepsis. Both animals died during their stay in the hospital.

There is limited information regarding the fertility of alpacas and llamas after undergoing a cesarean section. A retrospective study\(^14\) including 19 mares showed a considerable decrease in fertility following cesarean section. In a similar study of cesarean section in small ruminants, all animals that were rebred produced healthy offspring the following year without dystocia.\(^12\) There have been case reports\(^8\)\(^,\)\(^9\)\(^,\)\(^15\) of camelid cesarean section that suggest a good prognosis for subsequent fertility, but no report has evaluated subsequent fertility after cesarean section in a larger population of camelids. Of all camelids that were rebred after cesarean section in our study, only 2 were unable to conceive. These results suggest that subsequent fertility following cesarean section in camelids is not adversely affected. Most camelid patients also had a normal vaginal delivery following cesarean section. There was only 1 case of dystocia and 1 camelid having additional cesarean sections. The additional cesarean sections were done as elective procedures because of owner concerns about the ability of the dam to give birth vaginally. These concerns were likely unfounded given that the dam had a vaginal delivery of a healthy cria after having had 6 previous cesarean sections. All of these results show that it is not necessary to exclude an animal from rebreeding simply because the animal had a previous cesarean section.

The results of this study showed that a cesarean section is an effective method of resolving dystocia in camelids with a high survival rate and return to breeding soundness for the dam. The most common complication in camelids undergoing cesarean section is retained fetal membranes, which can be successfully treated and has a low morbidity rate. If fetal viability is in question during dystocia, prompt intervention with a cesarean section is recommended because fetal death has been associated with prolonged dystocia.

References