

# Indications for and outcomes of limb amputation in goats and sheep

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## OBJECTIVE

To characterize indications for and clinical outcomes of limb amputation in goats and sheep.

## DESIGN

Retrospective case series and observational study.

## ANIMALS

Goats (n = 15) and sheep (7) that underwent partial or complete limb amputation at the University of California-Davis Veterinary Medical Teaching Hospital from January 1, 1985, through December 31, 2015.

## PROCEDURES

Medical records of qualifying goats and sheep were reviewed and data extracted regarding signalment, use of animal, characteristics of the amputated limb, duration of hospitalization, outcome, and surgery-associated complications. The Fisher exact test was performed to compare postsurgical complication rates between various groups.

## RESULTS

Reasons for limb amputation included trauma (ie, fracture, dog bite, and wire-fence injury) and infectious or degenerative disease (ie, osteomyelitis and osteoarthritis). Median (range) hospitalization period for goats and sheep was 7.5 days (1 to 63 days) and 8 days (3 to 20 days), respectively. Most (7/9) of the postsurgical complications were noticed > 2 months after amputation and included uncoordinated gait, tendon breakdown and laxity of the contralateral limb, chronic lameness, surgical site infection, chronic intermittent pain, and angular limb deformity. No association was identified between postsurgical complication rate in goats and body weight category (< 20 vs ≥ 20 kg [44 lb]), age category (< 2 vs ≥ 2 years), and amputated limb type (forelimb vs hind limb).

## CONCLUSIONS AND CLINICAL RELEVANCE

Clinical outcomes for goats and sheep following limb amputation varied and were seemingly case dependent. Amputation should be considered when preservation of the whole limb is not possible. Veterinarians should advise owners that limb amputation may result in various complications and recommend after-care treatment such as physiotherapy. (*J Am Vet Med Assoc* 2018;252:860–863)

**M**usculoskeletal injuries of the limbs are fairly common among small ruminants evaluated in veterinary practice.<sup>1,2</sup> Although preservation of the entire limb is the most desirable outcome following severe musculoskeletal injury, poor prognosis for return to normal function or financial considerations may prevent this. In such instances, partial or full limb amputation is considered a valuable alternative to euthanasia.

Reasons for amputations in cattle include catastrophic injuries to the limbs that occur mostly on the farm (ie open, comminuted fractures of long bones), osteomyelitis, chronic septic arthritis, and severe laceration of muscles, tendons, or nerves.<sup>2</sup> Potential injuries requiring consideration of limb amputation in small ruminants are generally similar to these. Addi-

tionally, severe traumatic injuries in goats and sheep from dog or wild predator bites may require limb amputation as part of treatment.

Several factors are usually considered prior to limb amputation in veterinary species. In the authors' clinical experience, these factors include patient size, body weight, use of the animal, owner's commitment to providing physiotherapy following limb amputation, treatment costs, presence of pathological changes in the contralateral limb, and whether the forelimb or hind limb is affected. Thus, patient outcomes and long-term success following limb amputation can vary among species and individuals. Potential postsurgical complications in ruminants include breakdown of the contralateral limb, prolonged recumbency, persistent lameness, poor meat and milk production, and poor quality of life.

Limb amputation is widely practiced in small companion animal medicine, with up to 88% of dog owners reporting complete or nearly complete return

## ABBREVIATIONS

CI Confidence interval

to preamputation quality of life.<sup>3,4</sup> Limited research has been reported regarding clinical outcomes and long-term prognosis in cattle and horses following limb amputation. In a retrospective case series<sup>5</sup> involving 13 horses that underwent partial limb amputation, 4 horses were euthanized within 21 days after amputation, whereas 9 horses survived for periods ranging from 18 to 111 months. Reproductive performance decreased in most of these horses, with only 3 mares producing a foal and 1 stallion successfully completing 2 breeding seasons. In a case series<sup>6</sup> of limb amputation and prosthetic use in 3 cows (Jersey, Gelbvieh, and Angus), 2 cows developed carpal valgus deviation of the contralateral limb 18 and 20 months after limb amputation and were subsequently euthanized. The third cow (considered a companion animal) was reported by the owner as having a good quality of life and survived until 26 months after amputation, when bovine leukosis was diagnosed and the cow was euthanized.<sup>6</sup>

Goats and sheep have a lower adult body weight than cattle and might be suitable candidates for limb amputation following irreparable limb injury, yet to the authors' knowledge, no studies have been conducted to investigate this possibility. The objective of the study reported here was to characterize indications for and clinical outcomes of partial or complete limb amputation in goats and sheep.

## Materials and Methods

### Case selection criteria

Computerized medical records of the University of California-Davis Veterinary Medical Teaching Hospital were electronically searched to identify goats and sheep that underwent partial or complete limb amputation from January 1, 1985, to December 31, 2015. All patients identified through this search were included in the study.

### Medical records review

Information was collected from each patient's record regarding breed, age, sex, use of animal, body weight, nature of the injury necessitating amputation, identity of the amputated limb, location of amputation, duration of hospitalization, short- and long-term outcome, and complications associated with the surgery. Goats were classified as meat or dairy breeds or dwarf breeds. Sheep were classified as dairy or meat breeds or other breeds. Patient outcome was determined at 3 points: discharge from the hospital, 2 to 4 weeks after amputation, and > 2 months after amputation. Follow-up information was collected from owners via telephone or email.

### Amputation procedure

The same general amputation procedure had been followed for all goats and sheep. General anesthesia was first administered, and regional nerve blocks (brachial plexus or peroneal nerve) were provided by injection of bupivacaine (1 to 2 mg/kg [0.45

to 0.91 mg/lb]) in a ring pattern around the nerve, when applicable. An elliptical incision was made circumferentially through the skin just ventral to the proposed site of amputation. The underlying subcutaneous tissue was bluntly dissected, and muscles and vessels were ligated and transected as needed. When disarticulation was required, the collateral ligaments and other soft tissue structures were transected, and the distal portion of the limb was removed. When amputation was performed on a long bone, the limb was amputated by use of Gigli wire. In all situations, the muscle stumps were apposed over the bony end piece and sutured together with absorbable suture material in a simple interrupted suture pattern to cover the amputation site. The skin was closed with nonabsorbable suture material in a simple interrupted suture pattern.

Antimicrobials and analgesics (including NSAIDs and opioids) were administered to all patients before and after surgery. Physiotherapy, including passive range-of-motion exercises and sling support, was performed during hospitalization when indicated (ie, for recumbent animals or for animals struggling to walk) or at home to assist ambulation of the patient.

### Statistical analysis

Statistical software<sup>a</sup> was used for all analyses. Normality of distribution of continuous data (ie, age, body weight, and duration of hospitalization) was assessed with the Shapiro-Wilk test. Normally distributed data are reported as mean  $\pm$  SD, and nonnormally distributed data are reported as median (range).

Scatterplots were used to establish categories for body weight (< 20 and  $\geq$  20 kg [44 lb]) and age (< 2 and  $\geq$  2 years) for subsequent comparisons. To compare postsurgical complication rates (up to 1 year after surgery) between body weight categories, age categories, and affected limbs (forelimb vs hind limb), a 2 X 2 table was constructed and the Fisher exact test was performed. In instances in which a cell in the 2 X 2 table contained 0, a value of 0.5 was added to all 4 cells. Odds ratios and 95% CIs were estimated. Associations were considered significant if the OR was > 1 or < 1 and had a corresponding value of  $P < 0.05$ .

## Results

Fifteen goats (8 females and 7 males) and 7 sheep (5 females and 2 males) met the criteria for inclusion in the study. Median (range) age of goats was 2 years (21 days to 8 years) and of sheep was 1.9 years (30 days to 8 years). Median (range) body weight was 23.5 kg (51.7 lb; 4 to 65 kg [8.8 to 143 lb]) for goats and 32.5 kg (71.5 lb; 8 to 65 kg [17.6 to 143 lb]) for sheep.

Ten goats were of meat or dairy breeds (Nubian, LaMancha, Alpine, Cashmere, Saanen, Oberhasli, and San Clement), and 2 were of dwarf breeds (Pygmy); no breed was recorded for 3 goats. Five sheep were of meat or dairy breeds (Dorset, Barbados, and Santa Cruz); no breed was recorded for 2 sheep. Twelve

goats were considered companion animals, whereas 3 were raised for meat or milk production. All sheep were considered companion animals.

For goats, reasons for limb amputation included trauma (fracture [ $n = 8$ ], dog-bite wound [3], and wire-fence injury [1]) and infectious or degenerative disease (osteomyelitis [2] and osteoarthritis [1]). For sheep, reasons also included trauma (fracture [ $n = 2$ ], wire-fence injury [1], and severe degloving injury [1]) as well as infectious or degenerative disease (osteoarthritis [3]). Amputations in goats were performed at the level of the radius, ulna, or both ( $n = 4$ ); tibia (4); and femur (2), and the entire limb was removed in 5 goats (4 forelimbs and 1 hind limb). Amputations in sheep were performed at the level of the radius, ulna, or both ( $n = 2$ ); femur (2); humerus (1); and metatarsus (1) and via carpometacarpal disarticulation (1).

Antimicrobials administered in the perioperative period included ampicillin, ceftiofur, florfenicol, gentamicin, procaine penicillin G, and tulathromycin. Analgesics included flunixin meglumine, morphine, butorphanol, and fentanyl. Median (range) hospitalization period for goats was 7.5 days (1 to 63 days) and for sheep was 8 days (3 to 20 days).

All goats and sheep survived to hospital discharge. For 8 of the 15 goats, follow-up information was available for the period 2 to 4 weeks after amputation, and for 6 goats, it was available for the period > 2 months after amputation (range, 2 months to 1 year). By the 2- to 4-week follow-up point, 6 goats were able to ambulate well as reported by owners, whereas 1 goat was reported to have an uncoordinated gait (ie, hopping and stiff-appearing limbs) and 1 goat was reportedly unable to stand. Of the 6 goats that had been doing well 2 to 4 weeks after surgery, 2 goats were reportedly still able to ambulate well and had a good quality of life 2 months later, 1 goat developed a wound infection and laxity in the contralateral metacarpophalangeal joint at that time, 1 goat developed joint laxity in the contralateral limb 8 months after amputation and was euthanized, and 1 goat delivered triplets and was doing well a year after surgery. The goat that was never able to walk died from an unrelated cause (seizures) 6 months after amputation.

Follow-up information was available for only 2 sheep for the period 2 to 4 weeks after amputation, and these same 2 sheep also had information available for the period > 2 months after amputation (one sheep at 5 months and the other at 5.5 years after amputation). During this subsequent follow-up period, one sheep developed laxity in the contralateral limb and was managed with a leg brace, whereas the other sheep was reportedly able to ambulate but with periodic signs of mild pain (reluctance to stand and walk for long periods).

Overall, postsurgical complications (identified in 7 goats and 2 sheep with follow-up information) could be summarized as uncoordinated gait (1 goat), tendon breakdown and laxity of the contralateral

limb (1 goat), chronic intermittent lameness or signs of pain with absence of tendon breakdown of the contralateral limb (2 goats and 1 sheep), *Staphylococcus aureus* infection of the surgical site (1 goat), and angular limb deformity (2 goats and 1 sheep). For 2 goats, these complications had been noted 2 to 4 weeks after amputation, and for the other 5 goats and the 2 sheep, they had been noted > 2 months after amputation.

No significant difference was identified in postsurgical complication rates of any kind for goats weighing < 20 kg versus those weighing  $\geq$  20 kg (OR, 4.0; 95% CI, 0.2 to 64.0;  $P = 0.52$ ) or for goats < 2 years of age versus those  $\geq$  2 years of age (OR, 3.0; 95% CI, 0.3 to 35.4;  $P = 0.56$ ). There was also no difference for goats in which a forelimb versus hind limb was amputated (OR, 0.11; 95% CI, 0.01 to 1.41;  $P = 0.12$ ). No such comparisons were performed for sheep because only 2 had reported complications.

## Discussion

Findings of the present study suggested that indications for partial or complete limb amputation vary in goats and sheep. Most amputations in both species were performed in response to traumatic injury. No data have been reported regarding reasons for limb amputation in other domestic ruminant species, but the most common reason reported for limb amputation in dogs is neoplasia, whereas only a small proportion (10.9%) of dogs undergo amputation because of trauma.<sup>3</sup> This difference between species could be attributable to the general rarity of neoplasia of the long bones in goats and sheep.

A high proportion of goats and sheep in the present study were young (median age  $\leq$  2 years), suggesting that veterinarians and owners were likely to consider the age and use of the animal when determining whether to pursue limb amputation. In the authors' experience, veterinarians generally anticipate that young goats and sheep are more likely than their older counterparts to adapt to ambulation following amputation. In contrast, older goats and sheep may not tolerate general anesthesia and surgery well and are more likely to have preexisting disease conditions, such as osteoarthritis, thereby resulting in a poorer quality of life following amputation than might be achieved in younger animals.

In the study reported here, no significant association with postsurgical complication rate in goats was identified for age and body weight category, consistent with reported findings for dogs.<sup>4</sup> The authors' clinical experience suggests that ruminant owners are more likely to be hesitant about hind limb versus forelimb amputation. Their concern stems from the potential faster breakdown of the contralateral limb with hind limb versus forelimb amputation owing to the weight of the forestomachs, which is mainly supported by the hind limbs. Postsurgical complication rates were statistically similar for forelimb and hind limb amputations in

the present study, which is consistent with findings reported for dogs<sup>4,7</sup> and cats.<sup>7</sup>

Perioperative administration of antimicrobials and analgesics varied by patient in the present study and was based on the reason for the limb amputation and clinician's preference. All patients received general anesthesia for the amputation procedure, suggesting that general anesthesia might be the recommended anesthetic technique. Use of peripheral nerve blocks in addition to general anesthesia varied among patients as well. Peripheral nerve blocks have been recommended for sheep undergoing forelimb amputation<sup>8</sup> and dogs undergoing shoulder and elbow joint surgery.<sup>9</sup> Therefore, peripheral nerve blockade should be considered to provide balanced anesthesia and pain control for goats and sheep during limb amputation. The fairly brief hospitalization period in the present study (median, 7.5 days for goats and 8 days for sheep) given the nature of the surgery suggested that recovery of goats and sheep from limb amputation during the immediate postoperative period was fairly uncomplicated.

Postsurgical complications identified during the follow-up period in the present study varied among patients, and in practice, discussions about such complications are likely to vary on a case-by-case basis. Follow-up information was available for only a small number of goats and sheep; however, the available data indicated that most complications were noted > 2 months after amputation. Physiotherapy is an important part of rehabilitation following limb amputation in goats and sheep. Therefore, a client's willingness and ability to provide physiotherapy, such as encouraging the animal to stand, supporting it during standing, and encouraging it to walk, are important. Various veterinary orthotics and prosthetics have been used in the rehabilitation and pain management of dogs following limb amputation.<sup>10</sup> Studies evaluating the use of orthotics and prosthetics in goats and sheep are warranted.

In the study reported here, only a small number of goats and sheep met the inclusion criteria despite a prolonged (31-year) study period. This suggested that limb amputation is uncommon in these species. Possible owner concerns regarding limb amputation for their animals include cosmetic appearance after surgery, reduced mobility after surgery, guilt associated with limb amputation, perception of reduced quality of life, pain associated with the surgery, and concurrent osteoarthritis in the remaining limbs.<sup>3,4</sup> Additional concerns of goat and sheep owners could include an inability to closely monitor their animals' recovery and provide rehabilitation, given that most goats and sheep are not house pets.

Limitations of the present study included selection bias, a small sample size, and lack of sufficient follow-up information. Because the data were obtained at a single institution, the findings may have limited external validity. Finances, client compliance, and clinician expertise could have also influenced follow-up and postsurgical complication rates.

Limb amputation should be considered as an alternative to euthanasia in situations when the extent of the injury or financial restrictions preclude preservation of the limb. Whereas the prognosis for survival and recovery from surgery was excellent and short-term (2 to 4 weeks after amputation) prognosis was good for goats and sheep in the present study, more complications were reported > 2 months after surgery, and the nature varied among patients. No clear pattern could be identified to suggest that some patients might be more at risk of developing these complications than others. Veterinarians and owners should be aware of the potential for postsurgical complications, such as uncoordinated gait, tendon breakdown and laxity of the contralateral limb, chronic lameness, surgical site infection, and angular limb deformity in goats and sheep undergoing limb amputation.

## Footnotes

- a. GraphPad Prism, version 6, GraphPad Software Inc, La Jolla, Calif.

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