Angular Limb Deformity in Llamas and Alpacas

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Angular limb deformities (ALD) are common among llamas and alpacas. Veterinarians most commonly are asked to examine growing neonates for skeletal abnormalities, but these defects are not uncommon among adult llamas and alpacas. Owners may perceive that a mild angulation (< 5 degrees) in the forelimbs of adults is within the expected variation of normalcy. However, these angulations represent a skeletal defect and should not be encouraged as an acceptable phenotypic trait. ALD may be congenital or aquired. Congenital ALD most often is associated with prematurity. Premature neonates often have joint instability, presumably caused by immaturity of ligaments and surrounding muscle-tendon units. This results in altered weight bearing which causes eccentric loading of the physes of the limb. Physes respond to biomechanical loading by changing the growth rates within the physis. Thus, ALD worsens if the limbs do not achieve normal angulation within a few weeks of birth. If joint laxity does not progress to normal within 10 to 14 days of birth or if the angle is severe enough to interfere with ambulation, splints should be applied to the forelimbs to aid in establishing normal conformation. Splints are usually maintained for seven to 10 days and removed. The cause of aquired ALD is probably multifactorial and may include hypovitaminosis D, micro- or macromineral imbalances (e.g. copper, calcium, phosphorus), trauma, genetics, or may be secondary to other musculoskeletal defects (e.g. injuries on one limb resulting in altered weight bearing on the remaining limbs). Van Saun *et al*[4] found that young llamas and alpacas with hypophosphatemia and hypovitaminosis D had a high prevalance of skeletal defects including angulation to the limbs resulting from altered long bone growth. Thus, selection of an appropriate treatment is dependent upon the probable cause of the ALD. If multiple neonates on a given farm suffer ALD, then complete nutrition evaluation must be performed and should include determination of serum vitamin D concentration. Hypovitaminosis D is not uncommon in North America and may cause altered physeal growth and deviation of the long bones. Clinical experience suggests that the distal physisi of the ulna and radius are particularly susceptible to the effects of hypovitaminosis D, also referred to as hypophosphatemic ricketts.

Clinical evaluation

Llamas and alpacas have extensive hair growth on the limbs, often extending down to the foot. The presence of the hair may hide ALD from observation until later in life when the first shearing is done or until the owner begins to prepare the animals for exhibition. ALD is described by the joint most affected by the angulation and by the direction to which the limb distal to the angulation is deviated (valgus = lateral deviation, varus = medial deviation). Evaluation of the affected limbs should be done either after shearing of the limbs or by compressing the hair with bandage material wrapped firmly enough to see the contours of the limb. Paul-Murphy *et al*[1] found that the mean age of llamas examined for angular limb deformity was 6.2 months (range, 2.5 to 11 months). Males and females were equally represented and both forelimbs were affected in all animals.

Radiographic evaluation

Radiographic examination of the limbs should be done to assess the severity of the angulation, determine if other skeletal defects are present such as absence or abnormal formation of bones within the affected joint, and to guide treatment option selection. The severity of angulation is determined by measuring the angle formed by the intersection of two lines drawn along the central longitudinal axis of the affected bones using the dorsopalmar (-plantar) or craniocaudal views. Paul-Murphy *et al*[1] reported a range of ALD of 6 to 25 degrees in 28 llamas with forelimb valgus. The point of intersection of lines drawn on the craniocaudal radiographic projection images was at the radial physis (33 out of 56), radial metaphysis (20 out of 56), or radial epiphysis (three out of 56). Of 56 limbs examined, 14 had ALD of 5 to 10 degrees, 30 had ALD of 11 to 15 degrees, six had ALD of 16 to 20 degrees, and six had ALD of 21 to 25 degrees. Also, 58% of affected radii had curvature of the radius present upon intial examination. Metaphyseal flaring at the distal radial physis and distal ulnar physis was observed in 95% of the limbs examined. Of 41 limbs in which the third and fourth metacarpal bones were evaluated, 95% were found to have irregularities in the distal physis.

Treatment

This discussion will focus on carpal valgus originating at the level of the distal radius because this is the most common ALD requiring surgery and affecting llamas and alpacas. Congenital ALD is usually associated with laxity of the carpal joints and is usually self-correcting or managed successfully without surgery. Selection of the best surgical option for treatment of ALD is based on severity and age of the affected llama or alpaca. Surgical options include: hemicircumferential periosteal elevation ("periosteal stripping", HCP), transphyseal bridging (TPB), and corrective osteotomy (CO). Figure 1 outlines a decision flow chart that the author uses for selection of the appropriate surgical method. Little data is available concerning rate of growth and age at closure of the distal physis of the radius in llamas and alpacas. However, phenotypic growth slows or plateaus at 18 months old. Llamas and alpacas are assumed to be similar to foals in that growth of the distal physis of the radius slows before nine months old. Therefore, neonates < three months old are assumed to have sufficient growth potential such that HCP can be effective.

HCP is performed on the distal lateral aspect of the radius when the animal is young and the ALD is mild (< 10 degrees). The author prefers to perform a partial (1-cm long) ulna ostectomy at the time of HCP to ensure that growth restriction by the ulna does not occur. A 5-cm long incision is begun immediately proximal to the distal physis of the ulna and continued proximally. The periosteum is elevated from the radius and ulna and a large bone rongeur is used to remove a 1-cm long segment of the ulna. The periosteal elevation is continued cranially and caudally hemicircumferentially around the radius, and the periosteum is transected proximal and parallel to the distal physis of the radius. The periosteum is replaced against the radius and the skin is closed with an appositional suture pattern. A light pressure

Figure 1. Treatment decision flow chart for carpal valgus in llamas and alpacas.

ANGULAR LIMB DEFORMITY
⇓
⇓ ⇔ ⇓
< 10 degrees | > 10 degrees
⇔ ⇔
⇓ ⇓ ⇓ ⇓ ⇓
< 3 months | > 3 months | > 9 months | < 9 months | > 9 months
⇓ ⇓ ⇓ ⇓ ⇓
HCP only | HCP + TPB | CO | HCP + TPB | CO

HCP = hemicircumferential periosteal elevation
TPB = transphyseal bridging
CO = corrective osteotomy

Table 1. Drugs used to provide anesthesia or analgesia in camelids.

Use	Drug	Dose	Route
Sedation	Xylazine HCl	0.1 to 0.3 mg/kg	IV, IM, SC
	Butorphanol tartrate	0.03 to 0.1 mg/kg	IV, IM, SC
	Medetomidine	10 to 30 ug/kg	IM
General Anesthesia	Butorphanol + Xylazine + Ketamine	0.03 mg/kg 0.3 mg/kg 3 mg/kg	IM IM IM
	Tiletamine/zolazepam Halothane Isoflurane	4.7 to 6.0 mg/kg 1 to 5% 1 to 5%	IM OTT or NTT
Reversal Agents	Yohimbine	0.125 mg/kg	IV, IM
	Tolazoline†	1 to 2 mg/kg	IV, IM
	Atipamezole	0.125 mg/kg	IV

IV = intravenous; IM = intramuscular; OTT = orotracheal tube; NTT = nasotracheal tube.
† Caution: Acute death has been observed after rapid IV administration of tolazoline at high dosages.
+ = butorphanol, xylazine, and ketamine used in combination.
Adapted from Sarno *et al*[2] and Waldridge *et al*[5].

bandage is placed on the limb and maintained for seven to 14 days. Skin sutures are removed 14 to 21 days after surgery. The ALD should be re-evaluated 30 to 45 days after surgery to assess adequacy of correction.

TPB is done when the ALD is severe (>10 degrees) or the animal is older (e.g. closer to the time of limited growth potential in the distal physis of the radius). I usually chose to perform TB in neonates > three months old. I prefer to place needles at the intended location for screw placement and obtain a craniocaudal radiograph of the surgery site. One cortical bone screw (2.7 mm or 3.5 mm diameter screws) is placed proximal and one distal to the medial aspect of the distal radial physis. The approximate location of the distal physis of the radius can be located by inserting an 18-gauge needle firmly into the bone at intervals of 1 to 2 mm beginning immediately proximal to the metaphyseal prominence of the radius and continuing distally until soft bone is encountered and the needle can be seated for 0.5 cm. This procedure is more difficult to successfully perform in older neonates. Then, the screw hole is drilled, tapped, and a screw inserted parallel to the physis until 0.5 cm of the screw is left protruding from the bone. Orthopedic wire (18- to 20-gauge) is placed around the two screws in a "figure 8" pattern and twisted until secure. Then, the screw is inserted until firmly against the bone. The skin is closed and a pressure bandage applied. The pressure bandage is removed in seven to 10 days and skin sutures are removed after 14 to 21 days. The neonate must be examined daily to determine when the limbs are clinically straight, because over-correction is possible if the screws are not removed quickly enough after the limb is straight. The critical time period is determined by the age and growth rate of the neonate and the severity of the defect.

Corrective osteotomy may be performed after closure of the distal radial physis and when the severity of angulation precludes a good quality of life for the animal. Closing wedge ostectomy is the procedure of choice because this is more stable than opening wedge osteotomy. An open wedge osteotomy is made by performing an osteotomy at the distal aspect of the curvature and rotating the proximal fragment until the angle is corrected. Thus, a wedge-shaped gap remains on the concave side of the bone. A closing wedge ostectomy is performed by removing a wedge-shaped piece of bone approximately the size of the angle formed by the curvature. For closing wedge ostectomy, the bone wedge to be excised is estimated by drawing a line along the central axis from each end of the radius. The acute angle formed by the intersection of these lines is the degree of the arc of the wedge. An angle gauge is then applied such that the point of the wedge is on the concave cortex of the radius and the arc is on the convex aspect of the radius. The length of the arc is measured in cm and this measurement is used at surgery to estimate the size of the ostectomy. Squire *et al*[3] reported bilateral wedge ostectomy for correction of bilateral carpal valgus exceeding 40 degrees in a 48-month-old llama. Each limb was operated three weeks apart and a closing wedge ostectomy performed. The radius was stabilized using an orthopaedic bone plate (T-plate). The author successfully has performed several closing wedge ostectomies in llamas and alapacas and used transfixation pin casting or external skeletal fixation to stabilize the affected bone.

References

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